DENTAL HEALTH

IN

RURAL ZAMBIA

A report of observations made while serving as first dental officer to the Zambia Flying Doctor Service, 1967-68.

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"As civilisation makes its' unrelenting inroads on the few remaining primitive races, data of this type are becoming scarcer and scarcer and will soon be lost irretrievably. The time available for such studies is therefore very restricted and the urgency of the situation cannot be overstressed"

D. E. Barmes (1967)

"Every dentist should be a researcher whilst carrying out his clinical duties"

J. O. Akinosi (1979)

UNIVERSITY OF EDINBURGH

ABSTRACT OF THESIS (Regulation 7.9)

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In 1967 the Zambia Flying Doctor Service was constituted to provide medical and dental care to extremely remote rural communities where the primitive tribal life-style still existed. In the following year a basic oral health survey of primary school children was conducted in conjunction with clinical duties.

1,565 children were examined under standardised conditions according to the W.H.O. recommendations of the time. Of these, 1,440 were selected as a study group. They were drawn from three tribes, attended nine schools and had a sex ratio of boys to girls of 3:2. There was no birth certification.

Observations were made in each tribal territory of socio-economic conditions. The fluoride content of drinking water was analysed.

The accuracy of stated age as a parameter for data grouping in the absence of birth certification has been assessed. From the results the Zambian data were grouped according to dental maturation.

38% of children in the mixed dentition phase had caries in deciduous teeth with a mean value of 0.9 d teeth/child. No significant differences existed between sexes or tribes.

Caries prevalence in permanent teeth was 30-68% with 0.8 - 2.7 DT/child. Girls had greater caries experience than boys, and caries experience increased with development. There was significant geographical variation in permanent caries distribution which corresponded to the consumption of maize.

Periodontal disease occurred in 61% of boys and 46% of girls. 17% of boys and 8% of girls showed irreversible lesions. An association was found between oral hygiene status and periodontal disease status. Oral hygiene status and periodontal disease status were both associated with gross tooth malposition. Investigations into the possibility of an independent association between tooth malposition and periodontal pocketing were inconclusive.

These findings are discussed in the wider context with particular reference to the provision of oral health care in developing countries in Africa. Proposals are put forward to meet demand and need for oral health care in rural Zambia in different manpower situations, taking into consideration possible changes in dental disease status since the survey.

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CHAPTER FIVE

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PREFACE AND AIMS

By the late 1960's the aetiology of dental disease in advanced society had been closely examined. The role of refined carbohydrates in cariogenesis had been established and the association between periodontal disease and oral cleanliness had been demonstrated. However there had been relatively little documentation of dental disease in primitive society where refined carbohydrates did not exist and oral hygiene practice was limited to those aids available in nature.

Dentistry had been slow to reach the developing countries of Africa, where in remote rural communities the balance between dental disease and traditional tribal life could yet be undisturbed. The speed of socio-economic change, particularly in respect of diet, was however faster than the spread of dentistry, such that the primitive life style was fast disappearing unrecorded.

The appointment of a dental officer to the Zambia Flying Doctor Service in 1967 afforded a rare opportunity to observe dental health in isolated situations where western influences were still very slight.

This report describes how this opportunity was approached from both practical and academic standpoints: how the constraints of a primitive society impinged on dentistry: how a study in the form of a basic oral health survey was attempted, and relates the findings of that study to environmental conditions and provision of oral health care.

The aims of the study were

- to record and report on dental disease status in the absence of refined foods and manufactured aids for mouth cleaning.

- by the use of internationally recognised standard methods to attempt to provide comparative data for use in the wider context.

- to identify any group differences and to attempt to relate them to potential aetiological factors.

- to relate the recorded disease levels to the provision of appropriate oral health care, in the light of the particular social conditions and the existing manpower resources and distribution.

This task required close observation of the social and environmental conditions which are described in detail.

The field work yielded two research hypotheses. The first was that the distribution of dental caries might be associated with differences in staple diet. It was postulated that two carbohydrate foodstuffs :

maize - Zea mays Linn

and cassava - Manioc utilissima

as grown, stored and prepared in rural Zambia might have different roles in cariogenesis.

The second hypothesis was that the distribution and severity of periodontal disease might be associated not only with oral cleanliness but also with gross tooth malposition.

These hypotheses are investigated by retrospective analysis of the collected clinical data in which each is treated as an alternative hypothesis (H_1) to be accepted only when the Null hypothesis (H_o) is rejected on the strength of appropriate statistical tests.

The report is divided into six chapters. In Chapter One the general background to the study is described. Chapter Two is a review of the relevant literature. In Chapter Three the material of the study is described in detail and the suitability for dental study is discussed. In Chapter Four the methods are described and discussed. The clinical findings are presented and analysed in Chapter Five and discussed in Chapter Six.

CHAPTER ONE - BACKGROUND AND INTRODUCTION

Zambia - historical and geographical features

Social structure

Rural life

Health Care

The Study

CHAPTER ONE

BACKGROUND AND INTRODUCTION TO THE STUDY

PART ONE - ZAMBIA

Fig. 1 - Map of Central and Southern Africa

[i] The country of Zambia was created in 1964 when the former British Colony of Northern Rhodesia became an independent Republic within the Commonwealth. As shown in Fig. 1, Zambia is land-locked on the plateau of central Africa where it occupies 290,000 square miles. In 1967-68 the population was estimated to be approximately 4 million. The current figure is 5.6 million (Taylor 1982)

Relatively little is known about the early history of this region. Until the latter years of the nineteenth century the land was inhabited only by indigenous Bantu tribes who supplanted the original bushmen (Kay 1967). Visits by Arab and Portuguese slave traders have been recorded (de Lacerda 1798). In the nineteenth century Mission stations were established, mainly in the north eastern wing of the country, and the discovery of mineral wealth led to industrial development on a line running approximately north and south bisecting the country.

The twentieth century situation is one of a central axis of industrialisation consisting of ten towns connected by road, rail and air, surrounded by vast sparsely populated areas with only scattered outposts of European settlement (Appendix I, Fig. 1). In the 1960's according to Kay (1967) 40 percent of the population lived within 25 miles of the line of rail, giving an average population density for the rural areas of 10 per square mile, with less than 5 per square mile in some parts.

Communications in the rural areas depended almost entirely on an inadequate network of unsealed roads, leading to a high degree of isolation (Snaden 1971).

(ii) Location and regional inequalities have been identified as the two most crucial factors in Zambian life (Davies 1971a). Being landlocked the economy has largely depended on transport routes through neighbouring countries, and movement within the country is difficult due to the large distances and lack of roads.

The administrative capital is Lusaka, which is also the financial, commercial and industrial centre. The country is divided into eight provinces (Appendix I, Fig. 2) which are sub-divided into thirty districts. Siddle (1971) has commented upon the difficulties of administration in the rural areas owing to the size of the provinces, the poor communications and the widely scattered but numerically scant population.

Since independence the country has been governed by the United National Independence Party which, until 1973, was democratically elected. In that year the Constitution was changed such that the United National Independence Party became the only party.

By African standards, Zambia is relatively wealthy having in 1979 $500 G.N.P. per capita which in independent Africa is exceeded by only Cameroon, Nigeria and the Ivory Coast (Taylor 1982). The export of copper accounts for 95 per cent of the trade value (Kaunda 1971a).

(iii) The terrain of Zambia consists of a series of undulating plateaux of approximately 4,000 ft. above sea level, based on ancient sedimentary rocks with mineral-rich volcanic intrusions, but covered by shallow and predominantly infertile soils (Hall 1965). The few geographical features largely relate to the valleys of the main rivers, the Zambesi, which joined by the Kafue and Luangwa flows westward on the southern border ultimately to enter the Indian Ocean, and the Luapula which drains from the Banguelu swamp area in the north east to flow

via Lake Mweru, the Lualaba and the Congo rivers into the Atlantic Ocean. (Appendix I, Fig. 3).

Although Zambia lies wholly within the tropics, the altitude prevents excesses of temperature and humidity except in the lower lying river valleys. The climate is divided into three well defined seasons. From April to August the weather is cool and dry with no rain and temperatures averaging $60^{\circ}F$ ($16^{\circ}C$) in July, the coldest month. From August the temperature rises to give the hot dry season which, with temperatures averaging $75^{\circ}F$ ($24^{\circ}C$) in October, lasts until the rains break in late October or early November. The single rainy season lasts from November until April, when it is hot but with dense cloud cover and very few hours of sunshine. Mean rainfall during the wet months is estimated to be forty to sixty inches in northern areas and twenty to forty inches in the south (Kay 1967). From April till October there is no rain at all, the clear weather with light winds and little cloud providing over eight hours of sunshine per day (Brelsford 1960).

The majority of Zambia is covered with natural forest, woodland, or grassland, where only native subsistence agriculture is practised, commercial European farming being limited to the line of rail and a few outlying districts. The predominant vegetation as described by Mäckel (1971) is of open savannah type in which small trees of Brachystegia, Isoberlinia and Jubelnardia species occur, with little undergrowth, frequently broken by open areas called dambos. These are shallow linear

depressions where seepage and run-off water collects during the rains, only to dry up again as the dry season progresses. This type of woodland covers over half of Zambia, and particularly the area to the west of the railway. In the north east of the country there is a large area of swamp around Lake Banguelu, some areas of which become totally dry in the dry season.

Vegetation in this area is largely grass forming a papyrus sudd, with very few trees.

PART TWO - SOCIAL STRUCTURE

[i] The African population of Zambia includes a wide variety of distinctly different peoples, although all are ethnically similar in being Bantu*. The 1960 General List of Chiefs listed over eighty tribes in seven distinct language groups.

In 1967 tribal traditions remained strong in the rural areas which were still very isolated. This study is primarily concerned with three rural tribes, and to a lesser extent with a fourth. All four, i.e.

Kaonde	-	North Western Province
Kawende	-	Luapula Province
Bisa	-	Northern Province
Lamba**	-	Copperbelt Province

were included in the General List of Chiefs, and had defined boundaries and cultural identity. The distribution of the tribal territories is shown in Appendix I, Fig. 4.

Richards (1961) has described how these four tribes had features in common, i.e. dependence on agriculture, similarity of language and social custom. Differences occurred in

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* a linguistic classification used to differentiate Negro-Hamites from Nilo-Hamites to the north and the Khoisian group of Bushmen and Hottentots to the south (Cole 1967).

** the literature contains many variations of spelling of proper names in Africa. For this report tribal elders were consulted and it is their spelling which is used throughout. Other forms exist, e.g. Kabendi or Kawendi for Kawende; Wisa or Bawisa for Bisa. The prefix 'Ba' is generally found in older literature.

administration in that the Kaonde and Bisa had a well defined heirarchy ranging from an all-powerful Paramount Chief through various grades of lesser Chiefs to village headmen. The Kawende administration relied on an agglomeration of village headman led by one more powerful member. The central tribal structure of the Lamba tribe had been largely destroyed by industrialisation, but the remaining rural components were governed by powerful sub-chiefs. Within their areas of jurisdiction headmen or chiefs had complete social authority unless directed by more powerful members of their heirarchy (Kay 1967).

[ii] Family structure within the tribe was extremely complicated. Permanent marriage rarely existed, and although marriage customs were rigid and very much as described by Richards (1961) in her study of the large Bemba tribe, both men and women might have a number of partners.

The traditional education within the family provided children with the necessary skills of society based on subsistence agriculture. Both sexes had defined tasks in the yearly cycle of garden management. In addition boys were taught to hunt and fish while girls were prepared for early motherhood (Mwanakatwe 1968).

[iii] Since 1964 there had been a massive programme of educational expansion, particularly in the provision of rural primary schools where none had previously existed (Kaunda 1971b). The aim that every child aged seven could attend Grade I was theoretically achieved in 1968 although there were

distributional inequalities. This subject will be discussed in greater detail in Chapter Three.

PART THREE - RURAL LIFE

[i] Rural life in 1967 was simple. Houses were built of local materials, poles and mud with reed or grass thatch. There was virtually total dependence on natural resources. Trypanosomiasis restricted stock keeping (Foulkes 1981) such that the land was tilled manually using a variety of traditional methods based on bush-fallow and transitional ash-cultures.

The single rainy season allowed only one cereal harvest per year in the Kaonde territory where the staple was maize, (Zea. mays Linn.). The Kawende and Bisa tribes depended on the perennial starchy tuber of cassava (Manioc utilissima). Carbohydrate formed at least 80 percent of the diet and was consumed in the form of a stiff porridge supplemented with stewed relish when available. There was no milk. The poverty of rural Zambia has been described in detail by Richards (1961) who found that the daily dietary intake could be as low as 816 calories, while Nwosu (1973) reported that 74 percent of rural primary school-children in south west Zambia showed scientifically recognisable signs of malnourishment.

[ii] In common with other tropical countries there was a high infant mortality - stated to be 50 percent up to the age of five years (Kaplan 1974) caused primarily by pneumonia, childhood diarrhoea and protein calorie malnutrition (Jelliffe 1966). Seven other major conditions namely:

tuberculosis

anaemia

intestinal helminth infections

measles

whooping cough

malaria

accidents (particularly burns)

also contributed to disease in infancy. Endemic diseases were:

malaria

bilharzia

hookworm infestations

trypanosomiasis (in some areas only).

[iii] The First National Development Plan of 1966-70 showed the post-independence commitment to improve conditions in the rural areas. By 1967 effects of this plan were in evidence in the presence of agricultural advisors, improved communications by use of radio, educational and health service expansion (Davies 1971b). The Zambia Flying Doctor Service was established in 1967 to provide health care in the most remote areas, which were virtually inaccessible except by air.

PART FOUR - HEALTH CARE

[i] In 1967-68 health care was in the process of rapid transition. Stein (1971) has described the political intention to replace the localised, fragmented and curative services of the Colonial era with a nationwide system of socialised medicine with emphasis on prevention. The health budget of K10 million represented 7 percent of the total national expenditure, and provided K2 (approximately £1.05) per head of population per annum.

Rural health centres were being established to provide all services except hospitalisation and were staffed by a single locally-trained Medical Assistant, although staffing had not yet reached the target and some health centres lacked a Medical Assistant. Referral pathways to District General Hospitals and Central and Specialist Hospitals in major urban centres were developing. Medical and nursing staffing depended largely on expatriate qualified personnel. Local training programmes had not reached their targets. The University of Zambia Medical School had opened for pre-medical studies in 1966 but would not have an output until 1973. Despite the very considerable expansion of facilities which had occurred since 1964 the shortfall of qualified personnel was a major constraint to health care delivery.

[ii] The Zambia Flying Doctor Service was an experimental quasi-government organisation based at the Copperbelt town of Ndola

(Appendix I, Fig. 1). It had been established largely as a result of the personal initiative of the Director backed by interest from the President. After a two-year feasibility study at two clinics (Appendix I, Fig. 5) the constitution received Parliamentary approval in 1967, with all capital costs and 75 percent of current expenditure to be provided from the national health budget. Despite the funding from the Ministry of Health, the Service was administratively autonomous under the authority of a Board which itself was directly accountable to the President. The Board was responsible through the Director for policy, planning and administration.

The Service had a dual role. Provision of health care in the most remote areas was to be combined with rural development. These functions were perceived as being of equal importance. Although theoretically complementary to the developing national health services in the rural areas, the Service was not administratively integrated with them.

In 1967 the projected Service was intended to provide primary health care initially to nine rural clinics with expansion to twelve by the end of 1969. Selection of the sites was at the discretion of the Board.

At each site a grass airstrip was to be constructed on a self-help basis by the local community. When each airstrip was operational, clinic buildings were to be constructed in local materials as shown in Appendix I, Fig. 6. Each clinic was to be in radio communication with the headquarters at Ndola and

all other operational clinics. Each clinic was to be staffed by two Medical Orderlies (not necessarily with Medical Assistant training) who would be responsible for all day-to-day running, the care of in-patients, local liaison and interpretation for European personnel.

All fully qualified medical personnel, initially six doctors and seven nurses, were to be recruited from the United Kingdom on six month contracts. The short contract was intended to be attractive to the newly-qualified, and to fit in with post-qualification training.

A medical team was to consist of one doctor and one nurse who would visit a rural base clinic on a regular basis three times per week, and provide a General Practitioner service. A stand-by team would accompany patients when air ambulance facilities were required to bring referred and emergency patients to Ndola General Hospital.

Full duties were to be assumed immediately on arrival in the country and active participation was expected in rural development projects.

The transport and communciations systems were to be provided by a team of expatriate pilots, aircraft engineers and mechanics, all based at Ndola.

In addition to the medical staff, the Service was to employ one dental officer, to be recruited in the United Kingdom on the same conditions as the medical officers, whose duty would be to develop a dental service at the rural base clinics.

[iii] Despite many approaches through a variety of sources during the field work and in subsequent years it has proved to be extremely difficult to obtain useful information concerning dental services in Zambia. Postal enquiries have not been acknowledged, even when supported by the authority of the British High Commission. Telephone enquiries while in the country were met with rebuttal on the part of clerical staff of the Ministry of Health on the grounds that employment with the Flying Doctor Service did not entitle the author to access to official information.

In view of the political tension which existed at the time the Director of the Service advised that further enquiries should be dropped for fear of deportation. The validity of this attitude was demonstrated by the deportation of two European members of the Service staff and later of the Director himself.

Subsequent approaches from the United Kingdom through the Zambia High Commission in London and the British High Commission in Lusaka have proved fruitless. Consequently the following description of oral health care in Zambia is based

on personal observation and professional contacts during the field work, with some support from the very limited published facts.

At the time there was no Director of Dental Services, no oral health surveys had been carried out (F.D.I. 1977) and there was no evidence of a planned oral health care programme. Services were limited to major urban centres where the twenty practitioners (1 : 200,000 population) were distributed as follows:

Private practice	11
Government service	6
Private practice under contract to mining companies	3
	20

These practitioners were all expatriates of varying nationalities. There were no Zambian nationals in training overseas.

Oral health care in the rural areas was limited to that which could be provided by traditional healers or government Medical Assistants who had no specific training in that field.

In the towns private practitioners reached only a small fee-paying population, while the government dental officers were stretched by the needs for oral surgery and by the requirement to provide care for all expatriate government personnel. Owing to the pressure on the government dental officers, the majority of emergency treatment for relief of pain for the African population was carried out by Medical Assistants largely

working without supervision. Prevention was limited to the fluoridation of one water supply in Lusaka which served 75,000 people (F.D.I. 1977) and to the issue of a teaching manual on oral hygiene methods to primary schools.

There were plans to expand the government establishment to 22 dental officers and the first appointments were made at the end of 1968. Five years later this quota was apparently filled (Sims 1973a) although later figures show only 18 (F.D.I. 1977). The new appointments were intended to provide dental services at larger District Hospitals throughout the country, which are now stated to reach a quarter of the population.

Training of operating Dental Assistants had been abandoned for lack of suitably qualified recruits (Pole 1967). The requirement was 'failed Grade IV', i.e. with four years of primary education but failing to qualify for further primary schooling. Although Sims (1973a) described there being a school for Dental Auxiliaries with 15 graduates per year, later official figures (F.D.I. 1977) do not show the expected increase of operators which should result from such a training programme.

Preliminary efforts were in hand to constitute a national Dental Association and two meetings were convened in 1967. Despite good attendance, no further meetings were convened and the Association has been stated to be in the process of reconstitution in 1977.

It has not been possible to establish the financial resources allocated to public dental care.

Communications and supplies presented problems. Equipment had to be purchased from other countries and there was a lack of trained engineers for installation and maintenance. Laboratory technicians were few in number.

[iv] The decision to include a dental officer in the Flying Doctor Service establishment had stemmed from medical observation during the pilot study that there was both a demand and a need for dental care among the people of the Lamba tribe at the West One Clinic (Appendix I, fig. 5). No assessment had been made of the extent of either demand or need. In so far as any thought had been given to the structure of the dental service it had been assumed that emergency treatment for the relief of pain would be provided on a daily rotational basis at each of the base clinics in conjunction with medical visits, but there was an open remit for the dental officer to develop the project on her own initiative. This did not include the provision of care other than at the base clinics. There was to be no integration with existing dental services. No surgery or laboratory facilities were provided at Ndola.

Initially the dental contract was for six months only but early provision was made for renewal.

Chairside assistance was provided from the medical staff at first, followed by a qualified Dental Surgery Assistant recruited in the U.K. At the end of her six month contract, a member of the medical nursing team was permanently assigned to the

dental team. At first the only available equipment was a small kit of hand instruments and medicaments for pain relief which had been taken to Zambia in personal baggage.

Practical experience at the base clinics quickly revealed that demand alone would not justify a full time dental officer appointment if the catchment were restricted to areas of low population density. An application by District Medical Officers for specialist dental services to be provided by the Flying Doctor Service dental officer to rural government hospitals was refused by the Board.

However, applications by the headmasters of rural primary schools adjacent to the base clinics for routine dental care and surveillance of their pupils was approved by the Board.

The move from the original concept of a single-operator demand led service to a school based service required two policy changes. Firstly, in order that emergency cover should be available at all base clinics, the medical officers should receive basic training in simple procedures for the relief of dental pain; secondly, that the dental team should be allowed to reside at the base clinics during the week and thus reduce travelling time. These moves were approved.

Facilities for the dental team were to be provided by the local construction of clinic buildings, and where possible dental chairs (Appendix I, Figures 7 and 8). A portable

chair was lent by the government dental officer in Ndola (Appendix I, Figure 9). Foot engines and an appropriate battery of hand instruments were acquired from various sources.

An opportunity was thus created to combine clinical duties with a basic oral health survey, and the foundation for this study was laid.

PART FIVE - THE STUDY

[i] The Zambia Flying Doctor Service as it was planned in 1967 theoretically offered three conditions favourable to dental field study of primitive peoples in Africa, namely:

(a) Access to remote rural communities where isolation had perpetuated primitive traditions.

(b) Access to those communities at a strategic point in their social development, i.e. before the post-independence transition towards westernisation had had time to take effect.

(c) In-service contact with the communities which would provide both time and facility for situation analysis.

[ii] The feasibility of dental study under the conditions could not be fully assessed at the outset but four major constraints were immediately apparent:

(a) Those communities to which there was access had been selected for medical and political reasons. The possibility did not exist for independent access by dental personnel to communities other than those adjacent to the Service base clinics.

(b) As an agent of rural development the Flying Doctor Service itself promoted transition from the traditional way of life, such that time to study peoples unaffected by change was limited.

(c) Since the base clinics were to be sited in remote areas of low population density, the possibilities of assembling a study group of adequate size were limited.

(d) As an in-service project, any dental field work would be subordinate to the service commitment, which itself was subordinate to the commitments of the medical service.

In addition there were the inherent constraints of working in a large developing country in Africa,principally:

(a) lack of an adequate social frame, in particular lack of birth registration

(b) the possibility of failure of co-operation

(c) linguistic barriers

(d) transport difficulties

(e) uncertainty about supplies and equipment

(f) lack of clerical and laboratory support

coupled with the basic conditions under which any field work would have to be carried out.

[iii] Although the constraints were formidable, a simple epidemiological survey, confined to reporting of caries status, oral cleanliness and periodontal disease status appeared to be feasible. Oral mucosal diseases and dentofacial anomalies

might also be included. A pilot study was carried out at West One to establish methods. Subsequently approximately 1,500 children were examined and treated. The examination data was transcribed and brought back to the United Kingdom for retrospective analysis and presentation.

CHAPTER TWO - REVIEW OF LITERATURE

Observation of dental disease status in central Africa

Observation of dental disease status in the Africa Region

Cariogenicity of maize and cassava

Periodontal disease and tooth malposition

Oral health care in Africa

Summary

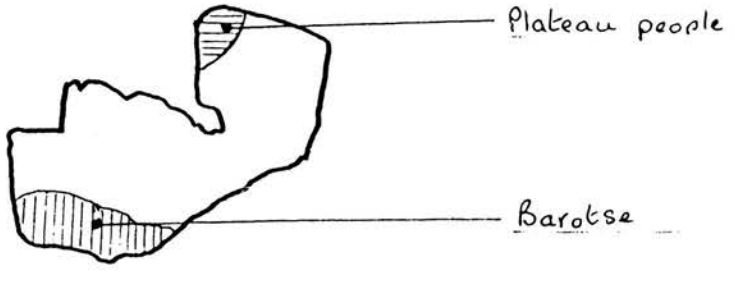
CHAPTER TWO

REVIEW OF LITERATURE

PART ONE - OBSERVATION OF DENTAL DISEASE STATUS IN CENTRAL AFRICA

[i] Over the last thirty years the body of dental literature from Africa has been strongly criticised for deficiencies in both quantity and quality. When reviewing the periodontal disease literature Dodds (1954) stressed its' "paucity and incidental nature", while fifteen years later Fox Taylor (1969) described the total body of literature from Africa as "meagre" and unable to support collation. The strength of these criticisms is particularly applicable in relation to the remote areas of central Africa.

In 1967-68 there were very few papers from central Africa despite the fact that early observation had indicated that dental diseases were prevalent among the tribes of the interior (de Lacerda 1798, Smee 1811, Livingstone 1856, Mummery 1870). In the early years of this century Colyer (1916, 1917), a government Medical Officer, wrote two descriptive papers concerning the dental health of the Barotse* and Plateau peoples of Zambia,



* now spelt BAROTZI

(then Northern Rhodesia), and these reports provided the major contribution to knowledge from this region.

Unlike many observers of dental health in Africa, Colyer included detailed descriptions of local conditions, social customs, crops and food preparation, and noted the frequency and practice of traditional oral hygiene methods. In this respect his two reports are extremely informative, and are still unequalled in the literature from such inaccessible parts. Unfortunately he included little quantitative data, and that lacked methodological definition.

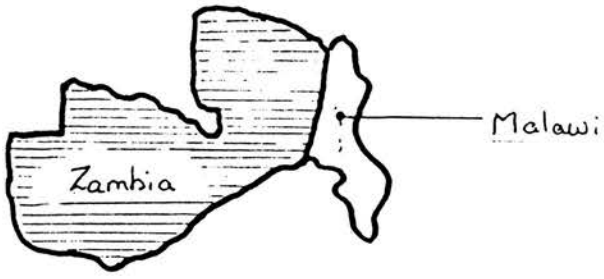
Dental caries was described as uncommon in children of the Barotzi tribe under ten years of age and recorded as present in 6 percent of those of the Plateau peoples estimated to be between ten and twenty years, with only 0.10 mean DT per child. It was recognised, however, that this was probably an under estimation since examination was only visual.

Colyer expressed surprise that caries prevalence was so low, since the diet consisted of soft carbohydrates and oral hygiene was poor, but attributed the low levels to the non-fermentable nature of the dietary substrate. It was his impression that caries prevalence was higher in the Barotzi tribe whose diet included a variety of cereals and the starchy root crop, cassava, than among the Plateau peoples who depended largely upon millet. He ascribed this difference to the introduction of non-indigenous crops by the Portugese, citing particularly the cultivation of sugar cane by the Barotzi which was grown in small quantities only.

He observed that periodontal disease was extremely common and very severe. In the group of Plateau people between ten and twenty years, prevalence was 97 percent with five percent already showing irreversible destructive lesions.

Oral hygiene was rarely practised among the Barotzi people and only a little more frequently by the Plateau tribes. Among those who did clean their mouths, either by swishing with water or rubbing the teeth and gingivae with salt, calculus deposits around the lower incisors were less evident. This was particularly noticeable in members of the police force and their families who were issued with salt for this purpose.

Contemporary with the observations of Colyer, those of Stannus (1914, 1917) in neighbouring Nyasaland (now Malawi) were also supported by social and dietary observation.



Among children of the Tonga tribe caries prevalence was again observed to be low with 8 percent of girls and 10 percent of boys affected with severity of 0.1 mean DT per child. Stannus also observed early destructive periodontal disease despite the diligence of the Atonga in the practice of oral hygiene except during illness.

By the late 1960's there had been only two further reports from centra Africa in addition to the early observations of Colyer and Stannus. Beet (1951) reported on dental health in children of the Lala tribe in Zambia giving some social and dietary details. Haphazard group selection and only superficial examination methods impair the value of the quantitative findings. In Rhodesia (now Zimbabwe) which borders Zambia to the south

Ritchie (1964) examined only urban children and as such his findings on caries status are not directly relevant to the present study.

[ii] In subsequent years the quantity of literature from central Africa has more than doubled with two further reports from Zimbabwe and five from Zambia, apart from those of the author which are included in Appendix 8.

Both papers from Zimbabwe included rural children but Ritchie (1975) did not present his findings for rural children separately. Muldoon (1973) did separate his findings for urban and rural children but gave little definition of

his rural material, merely stating that typical areas of Negro habitat were chosen. Without detailed knowledge of rural Zimbabwe this definition is unfortunately vague. However, his findings from a study using standard methods (W.H.O. 1971) for children of 12 - 13 years of age are the first clear figures to emerge for rural children in this region. Muldoon reported that in this age group the caries status was :

boys: 25% affected with 1.6 mean DMFT/child

girls: 36% affected with 1.7 mean DMFT/child

i.e. by present World Health Organisation criteria (W.H.O. 1980a) the levels were 'low'. Sadly Muldoon did not include findings for periodontal disease and oral hygiene status in this age group.

Comparison between caries experience in rural and urban children in this study showed higher experience associated with urbanisation, the first time this relationship had been demonstrated in central Africa, although it had been previously reported from other African countries (Littleton 1963, MacGregor 1964, Emslie 1964a, Akpabio 1966, Enwonwu 1966).

The more recent reports from Zambia itself are particularly disappointing, as with one possible exception (Desai 1973) standardised methods were not used. Desai gave no details of his methods in his very short paper, although the fact that his findings have been adopted by the World Health

Organisation and included in the Global Oral Epidemiological Data Bank (Barmes and Sardo Infirri 1977, Sardo Infirri 1981) indicate that he may have used standard methods. Enquiries to the World Health Organisation have failed to establish this point.

Of these reports, that of Ukeje (1971) was concerned entirely with urban children living in Lusaka who were examined during routine medical screening by para-medical personnel. Apart from demonstrating an apparent increase in caries prevalence between 1967 - 1971, and briefly touching upon the problems of age-grouping when chronological age is uncertain, this report is uninformative.

Andrik and Čech (1976) and Desai (1973) studied the dental health of school children in the Northern Province of Zambia which is essentially rural, although Desai worked within 17 miles of the township of Kasama. Neither report gives definition of the material which severely restricts the value of the findings. Since Andrik and Čech (1976) gave no indication at all how more than 1,000 Bemba children were assembled and examined radio-graphically their data are relatively meaningless.

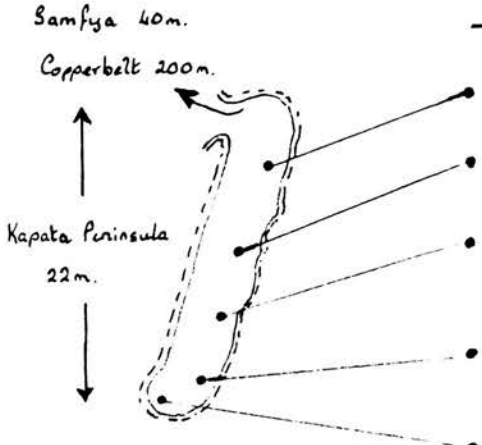
Without further information concerning Desai's methods his observations of very low caries experience must also be viewed with caution. It is interesting that one-year age groupings have been used in both these reports, with no consideration given to the point raised by Ukeje (1971) as to

potential inaccuracies in this procedure when exact chronological age is unknown.

The work of Sims (1973a, 1973b) in the rural areas of Zambia is of direct relevance, for he too was employed by the Zambia Flying Doctor Service, and was concerned with very much the same catchment as the present Study, five years later. Had Sims employed standard epidemiological methods there would have been an opportunity for valid comparison and evaluation of disease trends.

Unfortunately, Sims adopted a highly individual approach which coupled with his confused discursive presentation severely hinders interpretation of his findings. Lack of definition, muddled sampling procedures, cursory clinical examination, non-standard indices and arithmetical inaccuracies are present in both reports. Sims' conclusions are seldom supported by data, and to a reader with local knowledge it is apparent that this author has adopted an equivocal attitude to geography. For example, Sims' claim that his findings demonstrate an increase in caries experience with proximity to urbanisation, a reasonable supposition in the light of other findings in Africa, cannot be regarded as tenable. He has argued this point irrespective of different sampling procedures in the schools under consideration, and regardless of actual distances. (See Figure 2).

Fig. 2 Map of the Kapata peninsula in Lake Kampalombo to show relative distances between schools and figures upon which Sims (1973a, 1973b) based his argument that proximity to urbanisation increased caries prevalence.



School	No. examined by Sims	School * enrolment	Caries prevalence permanent teeth (Sims 1973a, b)
Chinsanka	74	75 - 80	45 %
Kaminsa	72	173 - 180	17 %
Mwaba	40	116 - 120	17 %
Chipundu	100	239 - 250	17 %
Twingi	130	268 - 280	17 %

* Figures for 1970 - 74 (Berkel 1975)

This author did however recognise the potential inaccuracy of stated age in rural Zambia, and he alone of all observers in Africa grouped his data by maturation.

PART TWO - OBSERVATION OF DENTAL DISEASE STATUS IN THE AFRICA REGION

Since the literature of direct geographical relevance proved to be generally uninformative, a wider examination of reports from Africa was made. For this purpose papers were initially selected in which observations had been made of the Bantu peoples who live south of a line stretching from Mount Cameroon to Mombasa.

Since this exercise did not yield many reports, the search was extended to include principal studies from the Africa Region excluding North Africa.

Particular attention was paid to relevance of material, i.e. observations of rural groups aged approximately 5 - 15 years with minimal western influences, and to standardisation of methods. Recent national surveys conducted on behalf of the World Health Organisation were not

included since they involve a high proportion of urban children and only the pooled data is presented (Sardo Infirri 1981).

Although this search yielded a large number of individual reports the same problems of interpretation were encountered as had been present in the literature from central Africa. In most cases there was little or no definition of the study material. As before the older papers,for example that of Orr and Gilks (1931) from Kenya gave more qualitative information, than recent studies, but lacked precise methodology. Some but by no means all of the more recent studies used standardised methods but failed to define their material.

In all only three reports could be selected as being of possible relevance in terms of both material and methods. These were two studies carried out on the same group in Uganda (Skougaard, Pindborg and Roed-Petersen, 1969; Mφller Pindbord and Roed-Petersen, 1972) and one from Mozambique (Hobdell and Cabral 1980).

These studies all included Bantu children stated to be of rural origin but no details were given of accessibility or diet. In all three the findings for rural children were pooled with those from urban schools.

It was therefore apparent that even a broad approach to the literature could not provide useful information concerning the dental health of rural African children in traditional society.

PART THREE - CARIOGENICITY OF MAIZE AND CASSAVA

The cariogenicity of individual items of diet in traditional African society is not a subject which has featured directly in recent literature. An early study in South Africa by Osborn and Noriskin (1937) into the cariogenicity of a range of traditional foodstuffs, including maize, failed to establish any relationships.

More recent papers concerning maize and cassava are studies of dental disease in relation to diet in broad terms, when neither food is implicated as being cariostatic or cariogenic (MacGregor 1963, Enwonwu 1974, 1978).

The cariogenic properties of maize flour in relation to milling methods were studied by Osborn Noriskin and Staz (1937) and Staz (1938), who found that caries did occur when the diet was based on whole maize flour prepared by traditional methods, and that in vitro solutions of whole maize flour were capable of producing enamel decalcification.

Steinkraus (1969) also found that, in the presence of six strains of streptococci, corn consistently produced titratable acids. No similar experiments appear to have been carried out on the properties of cassava flour.

PART FOUR - PERIODONTAL DISEASE AND TOOTH MALPOSITION

Among the Bantu peoples of Africa only two studies of periodontal disease in relation to tooth malposition have been published, with conflicting results. Davidow (1944) found that periodontal disease was more prevalent in a representative group of male adults than in a similar group selected for good arch form. Staz and Cohen (1947) who also studied adults, failed to find such a relationship. Neither of these reports is very convincing since both lack definition of the material and methods.

In the wider context there is now a considerable body of literature upon this subject in which the evidence of a relationship between periodontal health and tooth malposition, respective or irrespective of oral cleanliness, continues to be conflicting (Gould and Picton 1966). All studies in this subject however have been carried out in advanced societies where the dental profession is well established. There are no reports from primitive cultures where the absence of an active dental profession allows gross tooth malposition to develop free of interference.

Accordingly, although individually the studies are of considerable interest, and collectively the subject merits detailed discussion, no one paper can be selected as being directly relevant to this study and hence to warrant review at this stage.

PART FIVE - ORAL HEALTH CARE IN AFRICA

The literature contains very few references concerning the provision of dental services in the developing countries of Africa before 1969. The early papers from Upton (1945), Collins (1964), Emslie (1964a), Nevitt (1964) and Akpabio (1966) all stress the acute shortage of dental manpower. The last four authors emphasised the presing need for improvement which existed in the 1960's, since the available epidemiological evidence showed that dental disease was already increasing.

The three participants at the San Francisco Conference in 1964 did not however advocate the same course of action. Emslie (1964a) pressed the need for training facilities which he felt should be established under a co-ordinated World Health Organisation programme for the Africa Region. Collins (1964) regarded operator training as secondary in importance to prevention and research into possible preventive measures. Nevitt (1964) also advocated research, but into the aetiology of dental disease as found in the specific conditions prevailing in African countries. Akpabio (1966) acknowledged the magnitude of the problems but he offered no specific solutions.

The first evidence of Regional interest in oral health care to be found in the literature is the presence of four delegates from Africa at the W.H.O. Inter Regional Seminar of Training and Utilisation of Auxiliary Dental Personnel in New Delhi (W.H.O. 1968), and at the same time Rudko and Barmes (1968) expressed the view of the World Health Organisation that international co-operation would be

required in Africa if appropriate and effective oral health measures were to be introduced.

In 1969 the World Health Organisation convened the meeting of the Heads of Dental Services in the African Region in Lagos, which was the first occasion when the provision of dental services had been considered on a Regional basis. The Report (W.H.O. 1969) from Lagos is, therefore, the first authoritative document in this field from Africa. Sixteen countries (not including Zambia) were represented.

The tone of the Lagos meeting was not optimistic. Again the magnitude and diversity of problems in Africa was stressed. Deficiencies were identified in terms of administration and organisation of public dental health services, in manpower, in facilities and in lack of epidemiological data. The increasing burden of dental disease in developing countries was recognised.

Strong recommendations were made for future action, which in view of the importance of this meeting are given briefly here and in full in Appendix II.

Firstly, it was the opinion of the Conference that the only effective approach to the oral health problems would be in terms of public dental health services. It was recognised that where operator to population ratios were less than 1:80,000, as was the case in many countries of the Region, the first priority was provision of manpower. Secondly, it was recommended that national dental health administrators should be appointed, who should have the necessary political standing to implement the immediate introduction of preventive services.

To ensure effective planning, it was recommended that national oral health surveys should be carried out using epidemiological methods which should be standardised throughout the Region. If necessary this should be done with assistance from W.H.O.

Integration of oral health services with general health services was regarded as essential, and given the grave shortage of dental manpower for the foreseeable future, optimal use should be made of auxiliary personnel. The Conference was unanimous in its' opinion fluoridation would be the most effective preventive measure against dental caries and should be introduced in all countries of the Region at the earliest opportunity.

It was recognised that implementation of these recommendations would require international co-operation, and to that end the opinion was voiced that the World Health Organisation should establish a Regional Office for Dental Health Services with the appointment of a suitably qualified Regional Dental Advisor.

Although this Report must be regarded as the first major contribution in the literature concerning the provision of oral health services in Africa, and as such it represents a significant step forward in this field, nevertheless it has weaknesses. Firstly, only 16 out of a possible 38 countries were represented (Grappin 1978b) and as such the opinions and recommendations expressed were not those of the majority of developing countries in Africa. Secondly, the Conference did not display a clear appreciation of priorities nor the need for situation analysis which had already been advocated by W.H.O. (W.H.O. 1968).

Thirdly, little attention was given to the question of political motivation towards oral health, or to the organisation of the dental profession itself.

In subsequent years the volume of literature on this subject has increased, but many papers merely repeat topics discussed in Lagos (W.H.O. 1969) and have little if anything new to offer. Two authors - Grappin (1978a, 1978b) and Franklin (1978, 1979) - have attempted to identify the administrative causes of the continuing lack of progress in Africa which they attribute to the relative unimportance of dental disease in developing countries, to low manpower and to fragmentation of the profession.

In Ghana, Richardson (1972, 1979) has vigorously condemned the continuing lack of recognisable public dental administration in most countries of the Africa Region, and has defined a daunting number of controllable and non-controllable constraints facing those concerned in this field.

A realistic approach can also be found from Ana (1976) who has described the practical difficulties of establishing the training scheme in Nigeria, while Akinosi (1979) has again stressed the importance of epidemiological data in planning. This author advocated that clinicians in Africa should be more aware of the value of epidemiological data such that they could integrate data gathering with clinical duties.

Progress however has been reported from Senegal (Di Pasquale, Ndiaya and Thiam 1980, Di Pasquale and Thiam 1980, Di Pasquale and

Thiam 1981) and from Mozambique (Hobdell 1981) in the field of specialised auxiliary training for rural areas.

Nevertheless despite these references to individual national efforts, the Regional Expert Committee on Oral Health which met in Brazzaville in 1978 (W.H.O. 1979b) and the Conference on Oral Health Research Needs and Training which met in Lagos in 1982 (Anon 1982) were not optimistic about progress in the Region. Both reports largely repeated the recommendations of the earlier Lagos meeting (W.H.O. 1969) and again stressed the continuing need for international co-operation. Both again advocated the appointment of a W.H.O. Regional Advisor for Oral Health to be based at the Regional Office in Brazzaville, in order to promote international co-operation.

SUMMARY

In this review it has been shown that dental disease has been observed among the indigenous tribes of central Africa since the time of the early explorers, but there has been little scientific study of dental health in this location. Observations from the early twentieth century are valuable for social and dietary detail, but lack quantitative information.

More recent studies in rural areas of central Africa lack definition of material and show individuality of methodology which impedes interpretation of findings. No directly relevant reports could be identified in a search of the wider literature from the Africa Region.

The relative cariogenicity of traditional African foodstuffs has only been minimally considered in the literature. The limited available knowledge, which applies only to maize, indicates that in the presence of oral streptococci maise flour is capable of acid production and enamel destruction.

Periodontal disease in relation to tooth malposition has not been studied in depth in the dentally deprived peoples of Africa. The findings of the two available studies on this subject are conflicting as to the possibility of any association, but due to weak methodology neither is convincing.

The literature concerning the provision of dental services in the developing countries of Africa is pessimistic. It is generally recognised that the problems involved in oral health care are complex. Deficiencies of existing services have been identified as being primarily the result of:

Low priority afforded to oral health care

Lack of dental manpower

Fragmentation and isolation of the dental profession

Lack of strong dental administration

Lack of epidemiological data to assist planning.

It has been recognised that a planned preventive approach is necessary to meet the increasing dental needs in the changing societies of developing countries, and that such an approach will require international co-operation. It is thought that more active participation by the World Health Organisation would facilitate co-operation in the Africa Region.

CHAPTER THREE

Assembly and definition of the Study Group

Social and Environmental Conditions

Summary

Discussion

CHAPTER THREE

MATERIAL

PART ONE - ASSEMBLY AND DEFINITION OF THE STUDY GROUP

[i] Two factors principally dictated the availability of study material

a) the development of the Flying Doctor Service during the field work,

b) the educational system operating in rural Zambia at that time.

a) The siting of the rural base clinics of the Service was dictated by the endurance of the light aircraft used for access, these being Piper Aztecs (Appendix I, Fig. 6) and one Cessna 206. Limited re-fuelling was available at Samfya in the Luapula Province, and was arranged at Kasempa in the North Western Province. The nine sites selected are shown in Appendix III, Fig. 1.

The five clinics to the west of Ndola, respectively called West 1 - 5, lay in sparsely populated areas of Brachystegia woodland. East 1 and East 2, across the Congo pedicle from Ndola lay in the more densely populated areas of the Bangeulu swamp. East 3 and East 4 were sited in the very sparsely populated Luangwa valley.*

* The service notation, e.g. East 1, West 1, will be used throughout this report to denote a rural airstrip/base clinic complex. Locations, villages and schools will be given their African names.

During the first months regular access by air was achieved to West 1 and 2, East 1 and 2 clinics. The West 4 clinic was regularly approached by road from Kasempa. Intermittent access only was gained to the West 3 and 5, and the East 4 clinics. Due to failures of co-operation, the East 3 clinic could not be developed. By March 1968 all the eight developed clinics were regularly accessible by air during the dry season, although access was restricted during the rains.

Radio enquiries revealed that there were primary schools within easy access of six base clinics in addition to that at West 1 which was used for the pilot study. There was no school in the vicinity of the West 5 clinic. Clinic orderlies gave a provisional estimate of approximately 2,000 children being enrolled at the accessible schools.

Many requests were received from headmasters of schools which were not readily accessible from the clinics, where it would be impossible to carry out treatment. These schools were visited when possible by bicycle, truck or canoe to provide emergency treatment for the relief of pain but were excluded from the study.

Chief Macheya of the Lamba tribe refused to allow access to the three schools in his territory, and remained adamant despite prolonged attempts to meet him for discussion. Half the enrolled pupils at Lusemfwa school adjacent to the East 4 clinic had been excluded as the result of government policy which denied state education to Jehovah's Witnesses.

b) The emergent system of nation-wide State education was in the process of rapid expansion. In 1964, primary school places had been available to less than 70 percent of children with the most acute shortages being in the rural areas (Mwanakatwe 1968). The target of places being available for all children aged seven years was theoretically achieved by 1968. (Kaunda 1971b). The objective was to provide four years of primary schooling for all children, seven years of primary schooling for all urban children and 75 percent of rural children, and secondary schooling for one-third of suitably qualified primary school leavers.

Existing mission schools in the rural areas had been incorporated into the system. The curriculum was seven years

Lower primary	Grades I - IV
Upper primary	Grades V - VII

Progress was automatic through the lower primary grades, but there was a qualifying examination for admission to upper primary grades. School enrolment was not compulsory and attendance was not necessarily consecutive.

In deprived rural areas the expansion had been achieved by a 'self-help' programme of community involvement, with government assistance in the provision of building materials.

In practice the system was found to be confused. Linguistic barriers prevented free communication with headmasters, some

of whom resented enquiries. The Inspector of Schools for the Luapula Province was a European White Father from Twingi Mission on the Kapata Peninsula near to the East 1 clinic (Appendix III, Fig. 2), who was very informative about the system in that area. No similar authority was available for consultation in the North Western Province.

In his opinion, the system had several weaknesses,

i) not all communities had been equally active in the self-help programme

ii) population movements hindered the establishment of catchment areas

iii) inadequate provision had been made for children over the age of seven who at best might gain limited schooling and at worst none at all

iv) that the situation was complicated by lack of knowledge of chronological age (Berkel 1967).

Mwanakatwe (1968) stated that nation-wide a variable proportion of children eligible for schooling were not enrolled. Berkel (1967) estimated in his district that this could be 10 percent or less. He gave the following reasons for non-enrolment,

a) lack of clothes

b) lack of money for sports or 'comforts'

c) illness or deformity

d) obligation to work in the family gardens

e) religious principles

f) lack of interest particularly among older girls

g) being 'witched'.

He described the enrolment system as being a 'first come, first served' approach on a selected day when the first forty children claiming to be aged seven would be admitted to Grade I at the discretion of the individual headmaster.

It was therefore apparent that the majority of eligible children would attend school at some time but the exact proportion enrolled at any one time could not be accurately estimated.

[ii] Six base clinics gave access to a total of eleven schools, see Table 1.

Table 1 - To show schools accessible from rural base clinics.

Z.F.D.S. Base	School	Distance of School from Airstrip and Method of Access
WEST 1	MUSHINGASHI	School adjacent to clinic
WEST 3	NYOKA	School adjacent to clinic
WEST 4	MUSHIMA	Access gained initially from Kasempa by road. Later approached from W.4. and distance of 8 miles covered by bicycle.
EAST 1	CHINSANKA	2 miles - Children walked to the clinic.
	KAMINSA	½ mile - Children walked to the clinic.
	MWABA	5 miles - Bicycle.
	CHIPUNDU	8 miles - Bicycle.
	TWINGI	11 miles - Bicycle.
EAST 2	MOFU	School adjacent to clinic.
	KANSANSA	11 miles - Dugout canoe.
EAST 4	LUSEMFWA	1 mile - Bicycle.

Access to all schools except Kansansa could generally be gained throughout the year. Kansansa was on an island in the Banguelu swamp and could be reached by canoe at high water, by land at low water and was inaccessible for 3 - 4 months as the flood waters rose and fell.

[iii] The type of school and tribe of the pupils is shown in Table 2.

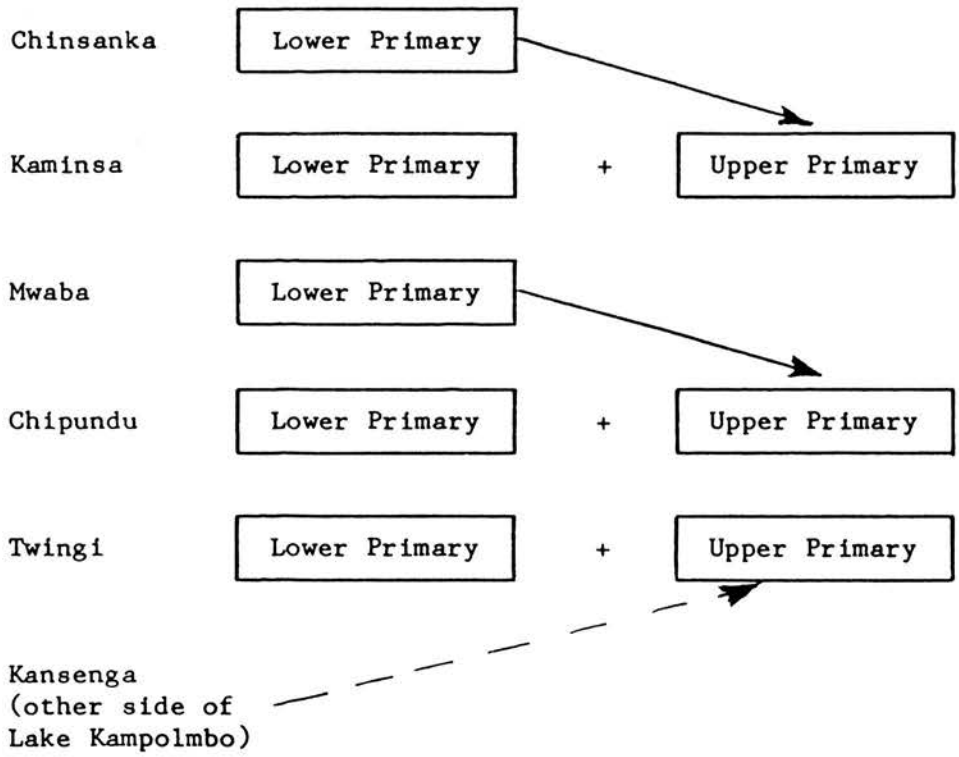
Table 2 - To show type of school and tribe of pupils

School	Type of School	Day / Boarding	Tribe
MUSHINGASHI	Grade I	Day	Lamba
NYOKA	Lower Primary	Day + Boarding	Kaonde
MUSHIMA	Lower Primary	Day + Boarding	Kaonde
CHINSANKA	Lower Primary	Day	Kawende
KAMINSA	Lower and Upper Primary	Day	Kawende
MWABA	Lower Primary	Day	Kawende
CHIPUNDU	Lower and Upper Primary	Day	Kawende
TWINGI	Lower and Upper Primary	Day + Boarding	Kawende and Unga
MOFU	Lower and Upper Primary	Day + Village Boarding	Bisa
KANSANSA	Lower Primary	Day + Boarding	Bisa
LUSEMFWA	Lower Primary	Day + Boarding	Mixed Swaka/Lala Lamba Luano

Twingi and Mofu schools had been mission schools prior to 1964 and been integrated into the post-independence system.

All the other schools had been established post-independence.

Mushingashi school was newly opened and offered only Grade I. Owing to the low population density in that area full enrolment of forty pupils had not been attained. The two schools in Kaonde territory, Nyoka and Mushima, offered lower primary grades only with children leaving the area for upper primary schooling. Of the five schools in Kawende territory Chinsanka and Mwaba offered lower primary grades only. The system of progression on the Kapata peninsula was as follows:



such that the children generally remained close to their own village throughout their education on the peninsula.

Children of the Unga tribe who entered the upper primary stream of Twingi school from Kansenga were described as having a similar life style to children of the Kawende tribe (Berkel 1967).

Bisa children from the remote Kansansa school enrolled at Mofu school for upper primary schooling. Children at Lusemfwa school left the area at that stage. All children left the area if eligible for secondary schooling.

Weekly boarding facilities were provided at five schools. Catering facilities were limited to the provision of relish foods which were cooked by the children and eaten with porridge of the staple crop provided by their families. The two Kaonde schools provided relish to be eaten at mid-day by all pupils. Boarders at Mofu school were lodged with families in the village and led the standard life of that community.

The catchment areas for schools in the West were ill-defined since the shifting agricultural system involved resettlement every few years. On the Kapata peninsula where settlement was more permanent, the catchment boundaries were clearly defined and adhered to. Exceptions occurred only in the continued enrolment of Christian children from the whole peninsula at Twingi school. The catchment at Mofu was defined on the landward side, but involved children from shifting fishing camps in the swamps, as did that of Kansansa. The catchment of Lusemfwa school was large and ill-defined.

[iv] A total of 1,565 were examined, distributed by school as shown in Table 3.

Table 3 - Distribution of all children examined by sex and school

School	M	F	TOTAL
MUSHINGASHI	26	10	36
NYOKA	54	58	112
MUSHIMA	67	41	108
CHINSANKA	51	26	77
KAMINSA	113	64	177
MWABA	76	43	119
CHIPUNDU	155	91	246
TWINGI	165	92	257
MOFU	185	87	272
KANSANSA	59	25	84
LUSEMFWA	42	35	77
	993	572	1,565

All enrolled pupils were examined except at Kaminsa school where three pupils were continuously absent; at Kansansa school where two had enrolled but never attended, and Lusemfwa school where only approximately half the number of enrolled pupils were in attendance.

The data from Lusemfwa school was excluded from the study group since only a proportion of enrolled pupils were available for examination. The data from Mushingashi school, which was atypical in having only one class, and represented only 2 percent of the total, was used for the pilot exercise only. Twelve further children were excluded from the study group since their dentitions were grossly mutilated by pathology or trauma. The distribution of the 1,440 children of the study group is shown in Table 4, stated age being that taken from the school register.

Table 4 - To show the distribution of the study group by sex and stated age

Stated Age	Boys	Girls	
6 -	14	12	
7 -	45	41	
8 -	83	86	
9 -	136	93	
10 -	144	105	
11 -	94	69	
12 -	114	51	
13 -	80	32	
14 -	83	23	
15 -	54	10	
16 -	40	3	
17 -	16	-	
18	12	-	
Total:	**915**	**525**	**1,440**

The lower overall proportion of girls and the relative absence of older girls reflected the national situation Mwanakatwe (1968).

The tribal distribution of

Kaonde	16 %
Kawende	60 %
Bisa	24 %

which is shown in detail in Appendix III, Table 1, reflected the relative population densities of the territories and was in accord with the respective Provincial enrolment figures (Kaunda 1971b).

The distribution by school (Appendix III, Tables 2 and 3) shows the lack of rectangularity, and wide age range of primary school pupils in the flexible educational system. For example, Kansansa school, which was lower primary grades only, had children enrolled who claimed to be eighteen. This was also seen at Mushingashi school which was used for the pilot study (Appendix III, Table 2).

Given the lack of birth registration, the pressures on the educational system and the relative autonomy of individual head-masters in the selection of entrants, little confidence was felt in the reliability of stated age. This will be examined in more detail in relation to data grouping.

283 children (20 percent of the study group) were weekly boarders, the proportion being higher among girls (23 percent) than boys (18 percent). The distribution is shown in Table 5.

Table 5 - Distribution of weekly boarders by sex and school

	BOYS		GIRLS		
School	**Day**	**Boarding**	**Day**	**Boarding**	
NYOKA	19	35	37	21	
MUSHIMA	36	31	19	22	
TWINGI	104	58	31	61	
KANSANSA	19	40	10	15	
	178	**164**	**97**	**119**	Total boarders = 283

Boarders represented 50 percent of children examined from the Kaonde tribe, 14 percent of the Kawende tribe and 16 percent of the Bisa tribe.

PART TWO - ENVIRONMENTAL AND SOCIAL CONDITIONS

[i] Residence at the rural base clinics throughout the field work provided the opportunity for close study of conditions at each location. By dint of careful liaison, and the acquisition of a degree of linguistic competence, bona fides was established at clinics, villages and schools, such that it was possible to observe and communicate with relative freedom.

The following description is largely based on personal observation, supported when possible by the literature or the views of informed Europeans. The aim of the exercise was to examine those facets of the traditional lifestyle which were then regarded as being associated with dental disease status (W.H.O. 1961, Russell 1966) namely:

diet
availability and consumption of refined carbohydrates
fluoride content of drinking water
the practice of oral hygiene
health

The comparative study of these factors is preceded by a general description of the environment, accessibility and social conditions.

[ii] The two schools which provided the Kaonde contingent of the study group, Nyoka and Mushima, were situated in isolated

villages of the same names. Nyoka village was adjacent to the West 3 base clinic. Mushima was eight miles from the West 4 clinic (Appendix III, Fig. 1). Both were of the traditional rural settlement form of the North Western Province in being small, (approximately twenty houses) and essentially temporary. The houses were made of wood and mud thatched with grass in the style described by Watson (1952).

Both villages were sited in the sparsely populated (<5 per square mile) Brachystegia woodlands of the region and were surrounded by an ever-increasing circle of gardens. Both were within the Kasempa Tsetse Fly Control area (Foulkes J. 1967).

Differences between the two villages were that Nyoka was on the banks of the river Lunga, a permanent water course, which in addition to one well which tapped surface water only, provided water for the village. The river also provided a source of fresh fish, but fishing was made hazardous by the presence of crocodiles and hippopotami. The river water was a vehicle of bilharzia. Mushima village depended on a similar well for water with seasonal supplies from a dambo. The onlyaccess to Nyoka village prior to the advent of the Flying Doctor Service was by forest paths from the Kasempa Mumbwa road, a distance of forty miles involving a crossing of the Lunga river. Mushima village was accessible by road from Kasempa, the road being little more than a track, negotiable only by vehicles with 4-wheel drive and frequently impassable during the rainy season.

The small rural town of Kasempa with a population of under 4,000 was the nearest centre to both villages (Nyoka approximately sixty miles, Mushima thirty-five miles). At Kasempa there was a Mission hospital with a European staff of twelve, and two shops with a limited range of Western goods available.

The Kawende contingent of the study group was drawn from the five schools on Kapata peninsula in Lake Kampalombo in the Banguelu basin of the Luapula and Northern Provinces (Appendix III, Fig. 1 and Fig. 2). Migration into the peninsula, described by Brelsford (1946), for the lake fishing had resulted in permanent settlement and high population density.

Berkel (1967) estimated that there were approximately 3,000 residents in an area 22 miles long by 1-1½ miles wide, (> 100/square mile).

The interior of the peninsula was heavily cultivated with cassava gardens, and some stands of cereal were seen at the northern end. Access could be gained by road from Samfya, a distance of forty miles, but here too the unsealed road became impassable during the rains, and travel was further complicated by an unreliable ferry which could be out of operation for days or weeks at a time.

There was a European presence on the Kapata peninsula, and had been for thirty years, in the staff of Twingi mission

at the southern extremity. The mission was permanently staffed by three White Fathers with whom the dental team lodged during the attendance at Twingi and Chipundu schools. Life was extremely simple at the mission, the Fathers largely living on game, fish and the products of their vegetable garden. They purchased all other supplies either at Samfya or Ndola.

Owing to the fishing in Lake Kampalombo, there was a long standing cash economy on the Kapata peninsula although there was little evidence of commercial activity at that time. There were ten shops which were supplied from Samfya by road. Inspection of the shops revealed that stocks were very limited and western goods were in short supply. On many occasions the only available goods were small household items; candles, matches, etc., which were brought by bicycle.

The two villages Mofu and Kansansa which provided the Bisa contingent of the study group were dissimilar. Mofu closely resembled the Kawende villages on the Kapata peninsula in being a permanent ribbon development extending for two miles along the edge of the flood plain, with dense cassava gardens on the landward side. Kansansa was essentially a fishing camp on an island in the swamps eleven miles from Mofu, with very primitive temporary reed houses.

Owing to its' position in the flood plain, Kansansa island

had been selected in 1965 for an experimental government scheme to grow rice. The crop had failed and the project had been abandoned. This scheme had not involved any European personnel (Grey 1967). The only European contact in the Bisa villages before the Flying Doctor Service had been annual visits from the White Fathers of Twingi Mission.

Mofu was accessible by an unsealed road from Luwingu, a small rural centre similar to Kasempa and Samfya, 65 miles away. The three shops in the village were supplied by this route and were found to be if anything less well stocked than the shops on the Kapata.

Kansansa was approached from Mofu by water during the six months of flood, when the journey by canoe took three hours. From August to October when the plain was dry access was possible by bicycle or on foot. In between when the water level was rising or falling, the island was inaccessible from any direction. There was no shop on the island.

Water at both Mofu and Kansansa was drawn from the swamp and carried bilharzia. In addition there were three surface wells at Mofu and one at Kansansa. A fourth well was dug at Mofu during the field work.

Traffic movements on all rural roads were very infrequent. Petrol was of limited availability and restricted to four gallons per month. Local movements were principally by bicycle, canoe or on foot. Itinerant peddlers were occasionally encountered

in the Bisa and Kawende territory but never in the Kaonde territory. Among the few goods which they carried by bicycle were cans of Coca Cola.

In broad terms the Bisa village of Kansansa was the most remote and primitive, followed by the Kaonde village of Nyoka. The Kaonde village of Mushima was only slightly more accessible, while the Kawende villages and the Bisa village of Mofu were the most accessible and developed.

The village of Mushingashi which provided the thirty-six children of the Lamba tribe who formed the pilot study group was atypical in being a creation of the Flying Doctor Service. During the medical pilot study rural development schemes had been established, a shop, a bakery, a carpenters workshop, etc., on the clinic campus which had attracted settlement. Although Mushingashi was remote except by air, it was more affected by western influences than the communities which provided the defined study group.

[iii] An extensive study of social conditions in rural Zambia was carried out among the people of the Bemba tribe of the Northern Province during the 1930's by Richards (1961). She stated that the common ancestry of tribes from the Lunda-Luba Empire, which included the three tribes of this study, imparted similarities of social organisation. The field observations in 1967-68 supported this view and revealed that little had changed in the pattern of rural life in the intervening thirty years.

Life in all the villages providing this study group revolved completely around the annual programme of labour which was necessary to produce food supplies. The routine was seen to be demanding, since all agricultural activities were carried out by hand. Enquiries revealed that division of labour was rigidly defined. Women's work included sowing, tending and gathering the harvest, preparing the food, cooking, cleaning, carrying water and firewood in addition to rearing the children.

The men's tasks were cutting trees in preparation of the gardens, burning the wood, building both huts and granaries, hunting and fishing.

The scarcity of young and middle aged men in the villages was noticeable, particularly among the Kaonde at Nyoka and Mushima, and when asked about this both Chief Nyoka and Chief Mushima admitted that the absence of men who had gone to the mines put a severe strain on village economy.

In these two villages new gardens had not been prepared and old gardens were being sown a second year, with resultant lowering of yields. Maintenance of huts and granaries had been neglected, while wild animals raided the gardens unmolested. Women, approached on this question, bemoaned the lack of meat and fish. This situation was found to be less acute among the Bisa, and least among the Kawende where fishing provided an incentive for the menfolk to remain.

Evidence of hunger was seen particularly among the Kaonde

where women showed the lethargy described by Richards (1961), and little children had the characteristic signs of Kwashiorkor.

Enquiries from all sources failed to reveal any preferential treatment for the pregnant and nursing mother, such as the eating of special lactifacient millet high in calcium as noted by Orr and Gilks (1931) among Kikuyu women. Similarly no evidence could be found of the practice of geophagy remarked on by the previous authors in Kenya, or by Livingstone (1870) in central Africa.

All babies were breast fed up to the age of at least two years with supplementary feeding of gruel given by hand from a few weeks. When put off the back at 2 - 3 years and breast feeding stopped, toddlers were usually cared for by older siblings, and had to compete for food. Infant mortality was high from approximately $2\frac{1}{2}$ - 5 years.

[iv] The diet was found to be basically similar in all villages, and very much as described by Colyer (1916) earlier this century. The basis of all meals was a porridge made from the prepared flour of the staple crop, which was eaten with a stewed relish when available. The staple crop of the Kaonde tribe was maize

(Zea mays Linn) while that of the Kawende and Bisa was cassava (Manihot utilissima spp.) with some maize being eaten by the Kawende at the northern end of the Kapata peninsula. The composition of these staples, taken from the nearest geographical analysis is shown in Appendix III, Table 4.

In the literature the staple crop of the Kaonde has been stated to be sorghum (Watson 1952) and apparently many parts of the tribe still grew this crop (Foulkes M. 1967) but at Nyoka and Mushima there had been a change to maize in the 1930's as a result of a government policy which Richards (1961) outlined. Inspection of the gardens at Nyoka and Mushima found that the majority of the growing cereal was maize with only a little sorghum which was specially grown for brewing. Cassava has been described as being the staple crop of the Bisa since introduced by the Portuguese in the mid-nineteenth century (Gouldesbury and Sheane 1911) but had been more recently adopted by the Kawende who previously grew millet (Kay 1967).

The maize eaten by the Kaonde was stored in traditional granaries (Kay 1971b). The dilapidated state of the granaries, the high humidity during the rains, and the temperatures predisposed to spoilage such as that described by Zeleny (1948). Inspection of the granaries in February and March revealed that there was very little stored grain at Nyoka and Mushima at that time of year, and it was mouldy, as was that in the granaries on the Kapata peninsula.

Cassava as eaten by Kawende and Bisa was a perennial crop which, with rotation, provides fresh roots for harvest all year round.

Preparation of the flour to make porridge was found to be done by exactly the same methods as those described in detail by Colyer (1916). Cassava roots were soaked, dried, cut up and pounded into flour in pestle and mortars. Dried maize cobs were similarly pounded then winnowed in flat baskets. The prepared flour of either crop was then sifted on to boiling water and cooked into a thick stodgy mass. Observation (and consumption) of the porridge showed that texture was elastic and glutinous as Colyer (1916) had found earlier, not hard and fibrous as described by Sims (1973a).

The relish eaten with the porridge always consisted of a stew of whatever foods were available, and there appeared to be little variety from place to place or from day to day. The composition of the principal constituents of relish is shown in Appendix III, Table 5.

Preparation of the relish simply involved the boiling of all available food in water for hours. Salt was expensive highly prized and very rarely seen to be used. No tribal differences in cooking methods could be detected.

In order to eat the food, the consumers sat round a communal bowl of prepared porridge, and pulled chunks off the mass by hand. These were moulded to have a depression

in the middle and were then dipped into the relish before eating. The greater share of the relish was consumed by the adult men; women and children being seen to have very little or, frequently, none at all.

Apart from the difference in their staple crops, dietary differences were observed in the protein content of the relish. Very little meat was eaten by the Kaonde and Kawende but the Bisa regularly ate snakes. Fish was not available at Mushima village, but eaten fresh and dried at Nyoka and by the Bisa. The Kawende always dried their fish, simply laying it out in the sun, a practice which Berkel (1967) and Foulkes J. (1967) associated with gastro intestinal disorders. A further difference was noted in the amount of ground nuts and ground nut oil used by the Bisa both at Mofu and Kansansa, apparently a long standing tribal practice (Gouldesbury and Sheane 1911). No natural milk was consumed anywhere at that time although the Flying Doctor Service provided dried milk at the clinics for infant feeding only. Wild berries and fruits were eaten seasonally in all locations, in addition to which the Kawende had banana trees as did the Bisa at Mofu, while at Kansansa there was citrus fruits, mango and pawpaw.

Wild honey was gathered by the Kaonde at Nyoka and Mushima where it was the property of the Chief and brewed into beer. The habit of eating honey was denied by Chiefs Nyoka and Mushima and their wives. Nevertheless since the method of collecting honey, which was to follow the honeyguide bird (Indicator indicator) to the hive, (Carr 1969) had

possibilities of abuse unbeknown to the Chiefs, clinic orderlies and the respective headmasters were questioned. They agreed that while it was theoretically possible for the children to 'scrump' honey, it was strictly taboo and practically very difficult, since the distances covered were great and the trees difficult to climb. They did not think that children could consume honey without detection.

The qualitative weaknesses of diets based on maize and cassava are well documented (F.A.O. 1953, Jones 1959, F.A.O. 1963), in that neither staple is adequate in itself, while Carr (1956) has shown that primitive cooking methods can result in reduction of the nutrient content of relish foods. The personal observation of hunger and malnutrition in rural Zambia was to be expected, and agrees with the contemporary observations of Howard (1967) who studied nutrition in Zambia.

It therefore appeared that all contingents of the study group were at risk of dietary deficiency, and had been particularly vulnerable during early childhood. Of the three tribes the risk was greatest among the children of the Kaonde tribe owing to the dependence on a single seasonal crop. The risk was least among the Bisa tribe who made the most use of available protein.

[v] Formal investigations of the availability and consumption of refined carbohydrates through the media of Chiefs, headmasters, orderlies and White Fathers revealed that per capita

consumption before the advent of the Flying Doctor Service had been minimal or non existant. Theoretically availability was greatest among the Kawende and the Bisa at Mofu where there were shops. Availability was lowest among the Kaonde at Nyoka and the Bisa on Kansansa island. Consumption among the Kaonde at Mushima was stated to be restricted to the Chief and his wives.

All authorities were in agreement that children would not have had access to supplies. This was confirmed informally in conversation with the women during regular 'knitting bees' held in the villages.

The introduction of a cash economy by the Flying Doctor Service and the establishment of shops and bakeries supplied by air from Ndola was causing a radical change in this situation, and determined the early timing of dental examination.

[vi] In view of the complex underlying geology of the region (Mountain 1968), and the seasonal fluctuation in the water table (Kay 1967), the possibility existed not only of geographical variation in fluoride content of the water, but also of seasonal variation such as that described by Ockerse and Meyer (1941) in South Africa. All sources were surface water which has been found in other parts of Africa to have dentally significant levels of fluoride, although not such high levels as has been found in ground water (Ockerse 1941a, 1941b, 1953).

The investigations into the fluoride content of drinking water which are described in detail in Chapter Four took account of this possibility. The results showed that the Kaonde children had the possibility of some protection from dental caries by the ingestion of fluoride although with a maximum of 0.3ppm (Table 9) the level was below the optimum of 0.6ppm for tropical countries (Møller et al 1972). The Kawende and Bisa children lacked even this degree of protection.

[vii] Colyer (1916) and Stannus (1917) have described oral cleansing by rinsing the mouth with water, rubbing the tissues with sand, ash or salt, and by the use of sticks but none of these were seen to be practised in rural Zambia except in the schools.

Oral hygiene using soft wood sticks was theoretically part of the primary school curriculum, and each school had reputedly been issued with a Ministry of Education directive giving detailed instruction as to method. This directive was available for inspection only at Nyoka and Mushima schools. That from Mushima school was borrowed and translated from the Chikaonde.

The advocated method was as follows:

(a) a twig approximately 6" long and $\frac{1}{4}$" diameter (see Fig. 5) was selected from a range of tree or shrub species, the favoured species being Acacia mollissima.

Fig. 3 Stick for oral cleaning at Nyoka school

(b) The twig was then dampened and hammered between stones.

(c) The mouth was rinsed with water and the teeth cleaned systematically using the tufted end, holding in either a pen or palm grip, cleaning all surfaces with strokes away from the gingival margin.

(d) The mouth was rinsed again and the twig discarded.

(e) All aspects of the teeth and gingivae were massaged briskly with a finger.

This procedure was found to be rigidly adhered to at the two Kaonde schools where it was possible to visit informally and observe the girls. All children at these schools had supervised oral hygiene after the mid-day meal, and the borders after the evening meal.

At Twingi school the boarding Kawende children also had supervised oral hygiene after the evening meal. At Mwaba school classroom instruction only was given. Neither instruction nor supervision was apparently given at any other school.

In view of the reticence among the staff to discuss the subject the matter was not pressed. Instead the children were asked at examination whether they cleaned their teeth. The answer was invariably 'yes' which was not supported by the clinical findings.

[viii] The only available source of information concerning health in these locations was the medical practitioners of the Service. Since their experience was limited they were guarded concerning patterns of disease. Nevertheless, there was agreement among them on the following points.

(a) Malaria, bilharzia and hookworm were common at all four clinics.

(b) The preponderance of acute illness, deficiency states and observed mortality was in babies and small children who suffered from -

malaria
measles
hookwork
gastro intestinal disorders
total calorie or protein calorie malnutrition

(c) Those few women examined during pregnancy all suffered from some degree of iron deficiency anaemia but otherwise were in better general health than might be expected

from the social condition.

(d) Very few children of school age attended clinics except for treatment of trauma.

(e) There was no readily apparent reason except possibly the question of trypanosomiasis among the Kaonde, to think that disease patterns differed significantly between the communities of this study.

Summary

During the eighteen months from July 1967 until December 1968 under the auspices of the Zambia Flying Doctor Service, a total of 1,565 children attending rural primary schools were dentally examined under standardised conditions. The children attended eleven different schools to which access was gained from six Flying Doctor Service base clinics.

In selecting a study group from the total material gathered, the children from two schools were excluded on the grounds that the schools did not conform in structure to the other nine, the two schools being Mushingashi and Lusemfwa. A further twelve children, ten boys and two girls, who were enrolled in the nine remaining schools were also excluded on the grounds that their dentitions were atypical. The final group selected for study consisted of 1,440 children, of whom 915 were boys and 525 were girls.

Examination of the study group in relation to the total school enrolment showed the geographical distribution was in approximate accord with relative population densities,

and that the children examined represented approximately 0.8 percent of the provincial primary school enrolment for 1968. The ratio of boys to girls was slightly higher than the national ratio.

There was a wide range of stated age in the study group, the reasons for which have been discussed, and a rapid drop in the number of girls after puberty.

The study group was drawn from three distinct tribal groups geographically widely separated and with some social and dietary differences. Factors found to be common to all areas were the simple traditional life style with total dependence on local resources, the possibility of dietary deficiencies and the vulnerability of infants to deficiency and disease.

Differences were found in the staple carbohydrates; that of the Kaonde tribe being maize, that of the Bisa cassava, and that of the Kawende being cassava with some localised consumption of maize. Consumption of primary protein was greatest in the Bisa and least in the Kaonde tribes. Intake of refined foodstuffs was generally very low or non existent, with availability being theoretically greatest for the Kawende and the Bisa at Mofu, and least for the Kaonde at Nyoka and the Bisa at Kansansa.

Only the Kaonde had fluoride in the drinking water throughout the year and that at 0.2ppm.

Oral hygiene was both taught and practised at the two Kaonde schools, taught but not practised in two of the five kawende schools with the exception of supervised boarders, and neither taught nor practised in the Bisa schools.

Several exotic diseases were endemic, and malnutrition was common, but there were apparently no significant group differences in general health between the locations of the study.

DISCUSSION

The material for this study has several obvious disadvantages for epidemiological study. Firstly the selection was circumstantial and the study group cannot be regarded as representative. This limits the value of the clinical findings.

Secondly, the material lacks rectangular structure and does not have equal numbers of boys and girls, being particularly deficient in older girls. This might have been expected given the experience of Ritchie (1975) in Rhodesia but again limits the value of the findings.

Thirdly, the material is not backed by accurate knowledge of age, which when considering age-related diseases is a severe obstacle to useful reporting.

It might be argued that these deficiences are a contra-indication to epidemiological study at that time. However delay would have inevitably resulted in the loss of potentially valuable data due to socio-economic change. Compromise was therefore inevitable.

The epidemiological deficiencies are offset by the calibre of the material, the principal value lying in the potential to provide information concerning dental disease status in unique environmental conditions. This value is enhanced by the degre of situation analysis made possible by the relative absence of physical and cultural barriers which have generally hampered dental field study in the primitive societies of Africa.

In practical terms the distribution of the material was well suited for comparative study in the division into three widely separated tribal groups, each represented by more than one school. The presence of day and boarding pupils is also an attribute. It is unfortunate that more children from the Lamba tribe could not be included and that poor school attendance at Lusemfwa prevented the establishment of a group of mixed tribe.

Numerically the study group is one of the largest ever assembled in rural Africa, which as the literature shows has always been a difficult field for dental observation.

CHAPTER FOUR - METHODS

Administrative methods

Clinical methods

Supplementary exercises

Data handling

Analytical methods

Discussion

CHAPTER FOUR

METHODS

INTRODUCTION

In 1967 dental epidemiology was a relatively new discipline and only two manuals were available for guidance in the field (W.H.O. 1961, 1962). Since then there have been continuing advances and modifications of approach. In this chapter the application of the early approach is described in detail with such modifications as the circumstances dictated.

In order to discuss this approach in the light of current thinking before proceeding to the presentation of the clinical findings in Chapter Five, certain of the methodological findings are presented in the text at the appropriate points.

PART ONE - ADMINISTRATIVE METHODS

(i) It was not possible to carry out a formal pilot study but there was a short period in 1967 when only the West 1 clinic was operational. This time was used for planning and to conduct an informal pilot study at Mushingashi school.

Pre-study training and calibration was undertaken of both the examiner and the European nurse who was acting as recorder. Practice recording sessions were carried out until total accuracy was achieved on twenty chartings on three successive occasions. This training was given to the two successive recorders.

The use of pre-coded survey forms was considered, and approaches were made to Edinburgh University and to the World Health Organisation. The time factor did not allow for the lengthy delays which would have been involved in this course so a simple record card (Appendix IV, Fig. 1) was devised and printed locally. This card had the advantage of being serviceable for both the survey and subsequent treatment, and that boxes forsafe transportation were readily available.

The 36 children attending Mushingashi school were examined on three successive occasions. They were seated in a borrowed portable dental chair with headrest in the open but not in direct sunlight, as no suitable building was available.

On the first occasion the examination regime was established. This included the assessment of dental caries and a basic assessment of the prevalence of periodontal diseases according to W.H.O. (1962) plus an elective assessment of periodontal disease intensity using Russell's Periodontal Index (W.H.O. 1961). Since it was apparent that debris and calculus might be found in practically every mouth, oral cleanliness was assessed using the Simplified Oral Hygiene Index (Green and Vermillion 1964) rather than the Oral Hygiene Index (Greene and Vermillion 1960).

In addition, an attempt was made to assess occlusion according to Angle (1898) and the presence of gross tooth malposition was noted. All these procedures were familiar to the examiner.

On the second occasion the examination regime was repeated in exactly the same form. By this time an estimate of the possibly numbers for the study was possible and it became apparent that the use of Russell's Periodontal Index would probably be too time consuming to be practicable.

It was therefore decided that, rather than abandon an elective assessment of periodontal disease intensity altogether, the partial index Ramfjord's Periodontal Disease Index (P.D.I.)also recommended by W.H.O. (1961) should be used. This was made possible by the Director of the Flying Doctor Service who telexed to the United Stated for the University of Michigan No. 0 pocket probes which were brought

to Zambia by a returning Flying Doctor Service pilot who had been in the United States to collect a new aircraft.

The P.D.I. was not familiar to the examiner so to become conversant with the procedure, twelve European members of staff were examined on two successive occasions. This procedure was then repeated on fifteen Bantu members of staff. Finally the examinations at Mushingashi were repeated using the P.D.I. in place of the PI.

Reproducibility was assessed at the time from the figures shown in Appendix IV, Table 1(a) which showed that examiner error was less than 3% in all procedures except the assessment of skeletal malocclusion. Retrospectively reproducibility has been more closely examined as shown in Appendix IV, Table 1(b-e), testing the quantitative caries data using the parametric 't' test for the comparison of two means in a paired case (Armitage 1971), and testing the qualitative data for oral hygiene and periodontal disease status using the non parametric Mann Whitney U test (Siegel 1956).

This examination showed that reproducibility was achieved except in one instance, that being the examination for debris on the third occasion. It is very likely however that these later observations reflect an increased interest in oral cleanliness among the children examined rather than methodological differences.

The regime established at Mushingashi was then applied during the study and will be described in detail under the heading of 'Clinical Methods' later in this chapter.

When, during the pilot study, the estimate of possible total numbers was made, it was apparent that more probes for caries diagnosis would be required than were at that time available. These were obtained from various sources (U.K., U.S.A., R.S.A., Rhodesia) and were of various calibres. In order to standardise them each was ground to a cylindrical profile of 3mm diameter with a hemispherical tip. The grinding was carried out by a skilled European aircraft machine tool technician using Vernier controlled equipment. The profile of each probe was thereafter routinely checked on return to Ndola from the bush.

The standardisation is described in detail, in Appendix IVa. The dimensions were chosen because bench examination of extracted teeth had indicated that the use of sharp probes in the presence of high-cusped tooth morphology might lead to over-estimation of the presence of caries (Appendix IV, Fig. 2).

(ii) Throughout the survey the team consisted of the author assisted by three successive European recorders. Two of these were nurses seconded from the medical staff, the third was a Bristol trained Dental Surgery Assistant. Local liaison was established through the medical orderlies at each of the rural base clinics.

(iii) With one exception, a personal visit was made to each school for the purposes of liaison prior to the examinations. Introductions were made to headmasters and staff, and the object of the exercise fully explained. The number of enrolled pupils was established and access gained to the school registers. A further visit was made by the nurse who filled in a numbered card for each child, entering name, sex, age and class from the registers. This preliminary work could not be done at Kansansa school owing to transport difficulties throgh the swamps, and was therefore done on the day of examination.

On the day of the examination, the nurse checked the school register as to which pupils were present in the appropriate classes. The children were then requested to attend the examination room, in groups of six or eight. The cards were distributed to the children in the waiting room or area by the nurse and the children were supervised by a clinic orderly. Those absent from school were examined at a later stage during the working involvement with each school.

(iv) a) In order to minimise any possible environmental changes introduced by the advent of the Flying Doctor Service, the examinations took place at the earliest opportunity when minimal acceptable conditions could be organised, i.e. the use of an adequate building and a chair with a fixed head rest. These conditions could not be fulfilled at Kansansa School where ad hoc arrangements were made.

b) All examinations took place indoors in either a clinic building (Appendix I, Fig. 7) or a school classroom, except at Kansansa where the primitive buildings did not admit sufficient light. At this location examinations took place out of doors, but in shade.

The children were seated, facing a window, in either a locally constructed wooden chair with head rest (Appendix I, Fig. 8) or a portable metal dental chair lent by the Government Dental Officer in Ndola (Appendix I, Fig. 9) as available. Neither could be transported by canoe to Kansansa where a long-backed folding canvas chair was used.

c) All examinations were carried out in natural daylight but not direct sunlight. (The battery operated map reading light attached to the chair in Appendix I, Fig. 8 was used only for treatment.)

The light intensity of the examination site was checked at all locations with the light meter of an Asahi Pentax Spotmatic camera. With a patient seated in the chair, facing the light from a window, the camera was set at

focal distance	18"
film speed	100 ASA
aperture	5.6
shutter speed	1/125 second

and the object viewed was the patient's anterior teeth with

the mouth half open. If the light meter failed to register adequately, conditions were changed until a satisfactory reading was achieved. On a few occasions, at the beginning of the rains, no adequate reading could be obtained. The exercise was then abandoned until conditions improved.

d) The instruments used for the survey were

Plane mouth mirrors
Standardised right-angled probes
Blunt calibrated periodontal probes
Michigan No. 0 periodontal probes

and were kept separate to those used for treatment. These instruments were cold sterilised in lined flat metal trays.

e) The clinical observations were called out by the examiner to the recorder who entered them on the card in permanent ink. The recorder sat at a table in sight of the examiner, except at Kansansa where no table was available and a makeshift arrangement was made with logs and boxes. The recorders interrupted the examination if they were in doubt as to an entry.

f) Throughout the field work, 104 blind duplicate examinations were done with at least one per session. These were organized by the recorder and clinic orderlies so that the examiner was in ignorance of when they would occur.

g) At the end of each day the cards were marshalled and checked. The nurse checked that the numbers were correct, matched duplicate examinations to their originals and calculated the individual scores for the oral hygiene and periodontal disease indices. The two components of the Simplified Oral Hygiene Index (Greene and Vermillion 1964) i.e. debris scores (D.I.-S) and calculus scores (C.I.-S) were calculated separately and to one decimal place as instructed by the authors for individual scores. Since there were no instructions given by the World Health Organisation (W.H.O. 1961) about the calculations of the Ramfjord's Periodontal Disease Index scores, these were calculated to two decimal places at this stage.

The cards were then personally perused, the numbers with caries in deciduous and/or permanent teeth, gingival inflammation, periodontal pocketing, skeletal malocclusion, gross local irregularities and pathologies and anomalies were counted and entered into a cumulative register which would provide a check for the process of transcription. Duplicate examinations were checked against their originals. The cards were stored at the base clinics in the care of clinic orderlies until such time that they could be personally taken by air back to Ndola for transcription.

The taking of clinical photographs was noted on the dental cards and a list made of those on each film. The photographs were matched on the cards and numbered accordingly as soon as possible after the examinations.

PART TWO - CLINICAL METHODS

(i) The clinical examination for all children took 7-8 minutes and the regime was as follows:

(a) visual assessment of dentofacial anomalies according to the recommendations of W.H.O. (1962) and disorders of mucosa teeth and bone, with clinical photographs such as those shown in Appendix IV, Figs. 3 and 4 when possible.

(b) assessment of skeletal relationship (angle 1898).

(c) assessment of oral cleanliness as recommended by W.H.O. (1961) but substituting the Simplified Oral Hygiene Index (Greene and Vermillion 1964) for the Oral Hygiene Index (Greene and Vermillion 1960).

(d) assessment of dental caries for all teeth present except third permanent molars according to the recommendations of W.H.O. (1962).

(e) assessment of occupation of a tooth space. Deciduous teeth were recorded as present if any part remained in situ. Permanent teeth were recorded as present if there was a breach of the mucosa and the tooth could be felt with a probe.

(f) basic assessment of periodonal disease according to W.H.O. (1962), with the examination terminating on the positive diagnosis of a pocket.

(g) elective assessment of periodontal disease using Ramfjord's Periodonal Disease Index (Ramfjord 1959) as modified and recommended by W.H.O. (1961).

Dentofacial anomalies were difficult to diagnose in view of cultural differences as to what would constitute disfigurement. Accordingly these conditions were only recorded when of the magnitude shown in Appendix IV, Figures 3 and 4 when it was likely that masticatory function would be impeded.

Owing to difficulties in reliably achieving centric occlusion, little confidence was felt in the diagnosis of skeletal relationship.

The minimum criteria for a positive diagnosis of caries was taken to be the perceptible entry of a standardised probe into softened dentine when applied with light but firm pressure.

The teeth were not dried before examination. Debris or calculus obscuring diagnosis was removed when on the occlusal surface. Deposits on cervical surfaces were not removed

since the pilot study had not revealed any cervical lesions.

Fifty-four children presented with retained roots of deciduous teeth in such a fragmentary condition that no estimate could be made of the previous history. In thirty of these cases the fragments were encased in heavy deposits of calculus such as that shown by Houpt and Botchway (1969), and surrounded by severe inflammation of the soft tissues. These teeth were not recorded as decayed.

The history of missing permanent teeth was established, and usually found to be the effect of trauma. Three children had attended for emergency carious extractions before the school examinations. No teeth had been filled.

In the absence of specific criteria for the diagnosis of gingival inflammation in the basic assessment (W.H.O. 1962) this condition was recorded when there was marked colour change of the margins or papillae, bleeding on digital palpation or obvious swelling. Since colour changes were masked to a variable degree by pigmentation, greater weight was given to the other two criteria, to reduce the subjectivity of positive diagnosis. Pocketing was recorded when pockets of 3 mm or more were present. This diagnosis does not differentiate between true and false pocketing.

The criteria for diagnosis of gingival inflammation in the elective assessment of periodontal disease were not

clearly defined for the scores of 1 and 2 (mild to moderately severe gingivitis) and a conservative approach was adopted. Despite the claim that the P.D.I. should be usable in field situations where radiographic examination would be impracticable, difficulties were encountered in drying the teeth without suction. The diagnosis of pocket depth in this technique ensured that only true pockets were recorded.

(ii) The findings of the 104 duplicate examinations are shown in Tables 6 and 7. In the findings for prevalence of diseases and conditions the greatest error (5 percent) was in the diagnosis of skeletal malocclusion. No significant differences were found between the first and second examinations in the use of the DMF, DI-S, CI-S and P.D.I. when the raw data were tested as before (p. 80) as shown in Appendix IV, Tables 2 (a - d).

Table 6 Findings of the 104 duplicate examinations for prevalence of caries in permanent teeth, periodontal disease, skeletal malocclusion and gross tooth malposition.

	1st Exam.		2nd Exam.		Reading Differences	Diff %
	No.	%	No.	%		
Caries in permanent teeth	49	47.1	49	47.1	4	0
Gingivitis (basic assessment)	38	36.5	38	36.5	2	0
Pocketing (basic assessment)	18	17.3	17	16.4	3	1
Skeletal malocclusion	36	34.6	41	39.4	13	5
Tooth malposition	33	31.7	33	31.7	0	0

Table 7 Findings of the 104 duplicate examinations for DMF, DI-S, CI-S and P.D.I. scores

INDEX	1st Exam	2nd Exam
Mean DT/child (SE)	1.39 (0.20)	1.37 (0.21)
Median DI-S score	1.3	1.3
Median CI-S score	1.2	1.2
Median P.D.I. score	0.33	0.33

PART THREE - SUPPLEMENTARY INVESTIGATIONS

[i] Two investigations were undertaken in addition to the clinical examination, the first being the recording of the heights and weights of the children of the study group. This exercise required a high standard of local building, and the transport and calibration of a weighing machine. The logistic problems coupled with the absence of reference standards led to the exercise being abandoned after the examinations at only one location (West 3).

The later publication of growth curves for some Zambian schoolchildren (Fisher and Davison 1970) does not provide useful information for comparison. The details of the exercise are therefore described in Appendix IVb.

[ii] The second investigation was the assessment of the fluoride content in the drinking water at all locations. This was undertaken with the co-operation of the Director of the Flying Doctor Service, the Consultant Pathologist of the Rhokana Mining Corporation in Kitwe who provided fluoride-free glass bottles for collection and arranged for the analysis to be done in his laboratories, and various personnel in the bush.

Methods

All water sources were identified and personally inspected except on Kansansa island. There were initially 19, distributed

as shown in Table 8, and a further well was dug at Mofu which was included when it became productive. All were sources of surface water.

Table 8 Distribution of sources of drinking water

LOCATION	WATER SOURCE	NUMBER
NYOKA	Chief Nyoka's well Village well River Lunga	3
MUSHIMA	Village well Dambo	2
KAPATA PENINSULA	7 Village wells Lake Kampalombo	8
MOFU	3 wells Swamp water	4
	Plus one well (dug later)	1
KANSANSA	1 well Swamp water	2
		20

Samples were collected at four times during the year to allow for seasonal variation.

(a) October - at the end of the dry season when fluoride levels could be expected to be highest.

(b) December - after approximately one month of the rainy season.

(c) April - at the end of the rainy season.

(d) July - in the middle of the dry season.

December was chosen rather than January/February for the rainy season collection as access to, and movement in the rural areas became progressively more difficult throughout the rains.

Four conditions were laid down by the laboratory:

A) that all samples should be collected on the same day.

B) collection should be made only in fluoride-free glass bottles provided by the laboratory.

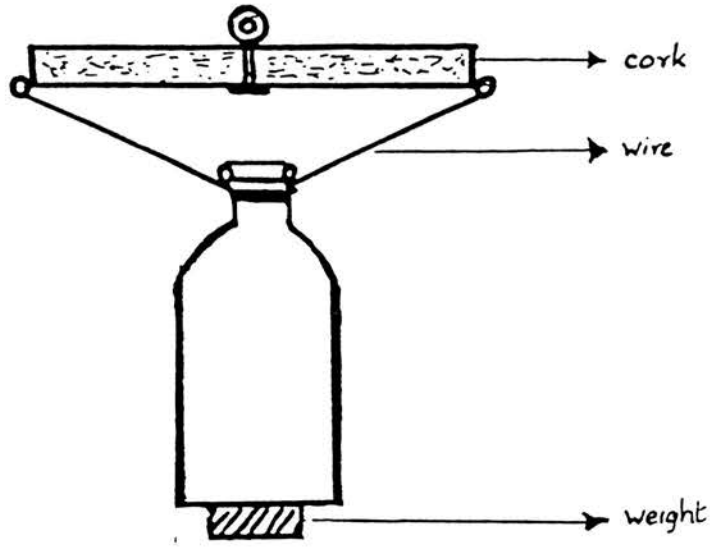
C) collection should be made from one inch below the level of water.

D) that all samples to be analysed should be delivered to the laboratory within twenty-four hours of collection.

To meet these conditions under the circumstances required careful planning and a high level of co-operation. A pilot was assigned to the exercise who was also a constructional engineer, and was himself in charge of well digging and water supplies for the base clinics.

At his direction a simple floating apparatus was designed whereby the collecting water bottle could be suspended vertically one inch below the surface of the water beneath a cork float - Fig. 4.

Fig. 4 - Float for collection of water samples



This apparatus could either be placed directly on the surface of accessible water, such as river, lake or dambo, or lowered into a well.

In planning the exercise, it had to be accepted that samples could not be taken from the well at Kansansa Island in December, since access was not possible at that season and in fact the July collection from Kansansa also proved not to be feasible as the swamps had not sufficiently dried up.

In the October exercise all water samples were collected either personally or by the pilot, with the exception of Kansansa where a clinic orderly from Mofu went by bicycle. In the December exercise, with the greater difficulties of transport in the rainy season it was necessary to delegate some of the collection. Father William Berkel of Twingi Mission undertook all the collections on the Kapata Peninsula, and the medical officer working at the West 4 clinic collected from Mushima village. The April and July collections were made without difficulty.

Findings

The results of the analyses are shown in Table 9, from which it can be seen that levels of approximately 0.2 ppm. were found at both Nyoka and Mushima in well water, with slight seasonal variation, but none was found in river or dambo. The only other sources with any fluoride at all were in two wells on the Kapata Peninsula which had 0.1 ppm. in October only.

Table 9 Fluoride content of drinking water

		October 1967	December 1967	April 1968	July 1968
WEST 3	WELL 1	0.3 ppm	0.2 ppm	0.2 ppm	0.2 ppm
	WELL 2	0.2 ppm	0.2 ppm	0.2 ppm	0.2 ppm
	RIVER	nil	nil	nil	nil
WEST 4 (Mushima Village)	WELL	0.2 ppm	0.1 ppm	0.2 ppm	0.2 ppm
	DAMBO	-	nil	nil	-
EAST 1 *	WELL 1	nil	nil	nil	nil
	WELL 2	0.1 ppm	nil	nil	nil
	WELL 3	nil	nil	nil	nil
	WELL 4	nil	nil	nil	nil
	WELL 5	0.1 ppm	nil	nil	nil
	WELL 6	nil	nil	nil	nil
	WELL 7	nil	nil	nil	nil
EAST 2 (Mofu)	WELL 1	nil	nil	nil	nil
	WELL 2	nil	nil	nil	nil
	WELL 3	nil	nil	nil	nil
	WELL 4	-	-	-	nil
	SWAMP	-	nil	nil	-
(Kansansa)	WELL	nil	-	nil	-
	SWAMP	-	-	nil	-

* Listed from north to south.

PART FOUR - DATA HANDLING

[i] The data were transcribed from the cards into a J.D. 8232 Croxley analysis book. The transcription was undertaken over a period of weeks and routine checking against the clinical register was carried out. The caries data were transcribed in full, including the site of lesions and teeth indicated for extraction, but only the scores calculated for each individual were entered for DI-S, CI-S, and PDI readings. The transcribed data were brought to the United Kingdom for tabulation and analysis.

[ii] In the first instance, the data were tabulated manually. Latterly the caries data were coded and entered into the University of London AMDAHL computer using the SPSS - X Release system.

The original intention was to calculate age specific prevalence of disease according to the directions of W.H.O. (1962) but on close examination of the data the doubts felt in the field as to the suitability of stated age as the parameter for data grouping deepened.

[iii] The recommended procedure for data grouping is still

tabulation by individual years of age up to the age of 15 (W.H.O. 1977) which presupposes that chronological age be accurately known. Three factors indicated that this procedure might not be appropriate.

(a) the frequency with which potential inaccuracy of stated age has been mentioned throughout the literature concerning the developing countries of Africa.

(b) field experience indicated that rural Zambian school-children did not accurately know their age, and that prior to the introduction of education chronological age had little or no social significance.

(c) when dental development was tabulated according to stated age as taken from the school registers as in Table 10, there was a remarkable degree of variation. Furthermore, dental development appears to be slow in the two schools Chipundu and Twingi with a history of European surveillance, i.e. those where the confidence in stated age would be greatest.

From the last observation it followed that it was possible that chronological age was being under-estimated in the other seven schools.

Table 10 To show mean number of permanent teeth erupted per stated age by sex and school for children claiming to be 8, 9 and 10 years.*

	BOYS			GIRLS		
	8 yrs	**9 yrs**	**10 yrs**	**8 yrs**	**9 yrs**	**10 yrs**
NYOKA	19.7	18.9	24.0	21.3	21.6	23.3
MUSHIMA	16.8	23.4	26.7	20.6	26.6	27.5
CHINSANKA	26.8	25.1	28.0	26.4	27.4	28.0
KAMINSA	15.7	21.0	22.9	19.7	21.8	26.2
MWABA	14.8	22.7	24.8	20.3	21.4	27.5
CHIPUNDU	14.9	15.9	20.2	13.4	20.7	22.4
TWINGI	12.4	14.6	19.6	17.4	17.2	23.3
MOFU	18.8	21.6	23.6	21.7	23.6	25.2
KANSANSA	21.8	21.0	22.3	22.7	25.7	24.3

* Data taken from Appendix IV, Table 4.

Investigations into the reliability of stated age were conducted in three parts:

(a) an analytical survey of the available data concerning dental development in relation to chronological age from other developing countries of Africa where birth certification was not mandatory. This investigation included an assessment of individual methods undertaken to establish the accuracy of stated age, and evaluation of the reliability of the observations.

(b) a comparison of findings from rural Zambia in relation to those in other African countries.

(c) an evaluation of the situation in rural Zambia using additional available information.

a) Material

The eruption times of permanent teeth (excluding third molars) have been studied in six African countries, namely:

South Africa	Suk (1919)
Kenya	MacKay and Martin (1952)
Ghana	Houpt Adu Aryée & Grainger (1967)
Uganda	Krumholt Roed-Petersen & Pindborg (1971)
Nigeria	Akpata (1971)
Togo	Richardson, Akpata, Ana and Franklin (1975)

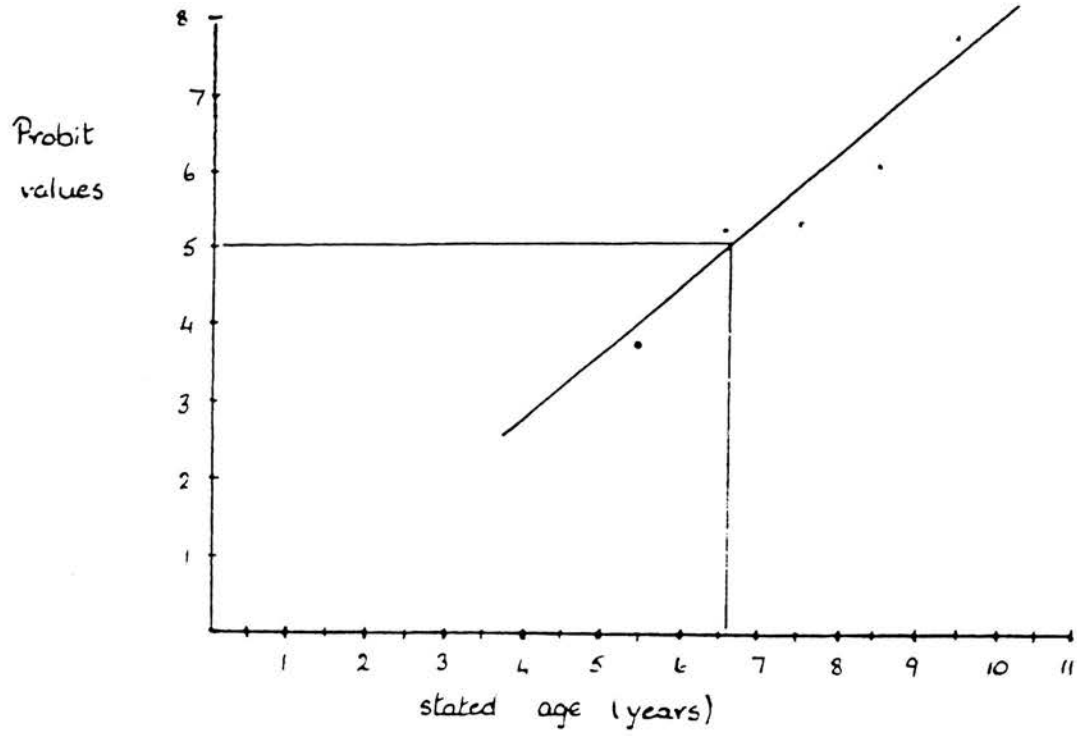
Of these only the first five studies included sufficient data to allow standardisation of the findings. Of these five studies three authors stated their criterion of eruption as being 'when a tooth had breached the mucosa' these three being Suk (1919), Krumholt et. al. (1971) and Akpata (1971). No criteria of eruption were given in the studies from Kenya and Ghana.

In South Africa reliance was placed by Suk (1919) upon the exact knowledge of birth date by Christianized children plus memory of historical events in others. In Kenya MacKay and Martin (1952) had some documentary support of age but relied upon verbal qualification by tribal elders. In Ghana Houpt et al. (1967) lacked documentary support completely and did not assess the accuracy of stated age by any other menas. Krumholt et al. (1971) in Uganda relied entirely on school registers trusting to natural compensation in the case of any inaccuracies. In Nigeria, Akpata (1971) examined only children whose age was supported by documentation.

Method

A comparison was made of the median eruption times of homologous pairs of permanent teeth. The median eruption time was graphically estimated from probit transformation of the data as expressed in terms of the percentage of teeth erupted per year of stated age. The percentages were converted to probit values by reference to appropriate conversion tables (Finney 1952), which were then plotted against stated age taking mid class intervals (Fig. 5).

Figure 5 Graphic estimation of median eruption times.



A perpendicular was dropped from the point at which a visually fitted straight line cut the probit value of 5.0, and the median read from the stated age axis. The median was estimated to two decimal points.

The median eruption times for each pair of homologous teeth were then compared using the Wilcoxon Matched-pairs Signed-rank test (Siegel 1956).

The data from Ghana, Nigeria and Uganda was presented by the authors in these terms, although a corrective factor of 0.5 year of stated age was added to the findings of Houpt et al. (1967) since they had not used mid class intervals. Since the data from South Africa and Kenya was not presented in terms of median eruption times the necessary calculations were made from the raw data presented by the authors including a check of bilaterality of eruption in the case of the South African findings.

Results

The standardised median eruption times are shown in Table 11, and the results of analysis are shown in Table 12.

Table 11 Standardised median eruption times of permanent teeth (yrs) from five African studies

TOOTH		SOUTH AFRICA Suk (1919)		KENYA McKay & Martin (1952)		UGANDA Krumholt et al. (1971)		GHANA Houpt et al. (1967a)		NIGERIA* Akpata (1971)	
		M	F	M	F	M	F	M	F	M	F
M	7	11.2	10.8	11.3	10.8	10.4	9.2	11.4	11.4	11.8	11.4
A	6	5.1	5.8	5.4	5.3	4.6	4.9	5.5	5.5	6.3	5.8
X	5	10.7	10.1	10.9	10.3	9.9	9.0	11.0	10.5	11.1	10.3
I	4	10.0	9.8	10.0	9.6	8.5	8.3	10.0	9.5	10.6	10.1
L	3	10.2	9.5	10.7	10.2	9.5	9.1	10.9	10.0	11.0	10.2
L	2	7.0	7.2	8.1	7.7	6.8	6.3	8.0	7.8	8.3	8.0
A	1	5.8	6.2	6.9	6.5	5.6	5.6	6.8	6.5	7.5	7.1
M	1	5.6	5.7	5.8	5.8	5.1	4.9	5.8	5.6	6.3	5.8
A	2	5.8	6.2	6.9	6.4	5.7	5.6	6.6	6.9	7.3	7.3
N	3	9.5	9.0	10.3	9.5	9.0	7.5	10.5	9.4	10.6	9.9
D	4	10.0	9.7	10.2	9.6	9.1	8.2	10.3	9.7	10.7	9.9
I	5	10.7	10.0	11.0	10.7	9.5	9.1	11.1	10.8	10.9	10.6
B	6	5.0	4.9	5.4	5.1	4.8	4.6	5.4	5.0	6.0	5.8
L	7	11.1	10.2	11.2	10.3	9.5	8.8	11.3	11.0	11.3	10.9
E											

* Certified age

Table 12 Results of analysis of data in Table 11 using Wilcoxon Matched-pairs Signed-ranks test (Siegel 1956) (P = probability values)

P	NIGERIA	GHANA	KENYA	S. AFRICA	UGANDA
	M < 0.01				
	F < 0.01				
	M < 0.01	M n.s.			
	F < 0.01	F n.s.			
	M < 0.01	M < 0.01	M < 0.01		
	F < 0.01	F < 0.01	F < 0.05		
	M < 0.01	M < 0.01	M < 0.01	M < 0.01	
	F < 0.01	F < 0.01	F < 0.01	F < 0.01	

These results show that eruption of permanent teeth was slowest in age-certificated Nigerian children, and earliest in the Ugandan group, where confidence was placed in the accuracy of school registers. In those groups where some attempts had been made to support stated age, the results fell between the two extremes.

Discussion

These results appear to show a wide variation in dental

development in relation to age among indigenous children in Africa. However the pattern of variation also corresponds to the efforts made to support stated age. Where certification was present eruption times were closer to those found in Caucasian children. Indeed in their comparative study Richardson et al. (1975) did not find significant differences between age-certificated children from Togo and children from Belfast. These findings might be taken to indicate that the apparent variation could be the result of misplaced confidence in stated age and not reflect true clinical variation.

Close examination of the supporting evidence supports this view. In South Africa, Suk (1919) relied to some extent upon memory of historical events, ranging from the great Zulu War of 1879 to the last Zulu rebellion of 1907, while his field work was carried out in 1913-1914. In his estimation it was possible to ascertain the age of practically all the subjects examined with a fair degree of accuracy.

In Kenya, MacKay and Martin (1952) reported up to nine permanent teeth erupted in girls estimated to be between 2 - 3 years of age. In Uganda the evidence of Carothers (1947), Chagula (1960) and Wiltshire (1979) shows that pressure for school entry has caused under-statement of age and hence that school registers are not necessarily reliable as was assumed by Krumholt et al. (1971).

These factors cast further doubts upon the reports of early dental development particularly that from Uganda. This

investigation indicated that in African countries without mandatory birth registration confidence might be misplaced in the accuracy of stated age, unless supported by positive documentation, and that the apparent trend was for age to be underestimated.

b) Material and Methods

The field data from Zambia were treated in the same way as described in section [i] of these investigations, i.e. the numbers of each permanent tooth erupted (having breached the mucosa) were calculated and expressed as percentages (Appendix IV, Table 5) for each year of stated age. The median eruption times were then graphically estimated for those teeth supported by adequate data, i.e.

canines

premolars

second molars.

Bilaterality of eruption was checked (Appendix IV, Table 6), the percentages for homologous pairs of teeth were pooled (Appendix IV, Table 7). The median eruption times for homologous pairs were then graphically estimated and compared with the equivalent findings from the other five reports from Africa.

Results

The median eruption times for eight pairs of homologous teeth in rural Zambian children calculated on the basis of stated age are shown in Table 13.

Table 13 Median eruption times for 8 pairs of homologous teeth in rural Zambian schoolchildren calculated on the basis of stated age

Homologous Pairs	Median eruption time in yrs. - M.	Median eruption time in yrs. - F.
upper second molar	9.7	9.3
upper second premolar	9.5	8.9
upper first premolar	8.5	7.7
upper canine	9.0	8.0
lower canine	8.2	7.3
lower first premolar	8.8	7.2
lower second premolar	9.7	9.0
lower second molar	9.7	8.9

Comparison of these findings with those in Table 11 showed that dental development was apparently significantly earlier ($P < 0.01$) in rural Zambian children than children from South Africa, Kenya, Ghana and Nigeria. Although eruption was found to be earlier than in Ugandan children, the difference did not exceed 95 percent confidence limits.

Discussion and Conclusions

It has already been shown as a result of the previous investigation that the early eruption reported by Krumholt et al. (1971) in Ugandan children could not be viewed with confidence. The finding that dental development was apparently even more

advanced in socially and medically deprived children in rural Zambia can only be regarded with considerable suspicion. Given the educational pressures for under-statement of age, it was concluded from this investigation that little reliance could be placed on the school registers and that statements of chronological age should be regarded as suspect.

c) **Material and Methods**

Within the Zambian study group 54 children attending Twingi and Chipundu schools had been baptised as infants by the White Fathers of Twingi Mission. The ceremonies were estimated by the Fathers probably to have taken place within two years of birth. The date of baptism was recorded at the Mission.

These dates were extracted from the church register and compared with the ages recorded for those children on the school registers. These were found to agree to within two years.

Of the children who had been baptised, only thirteen were in the mixed dentition phase which did not provide sufficient data to carry out an investigation of median eruption times. Dental development was therefore calculated in terms of the mean number of permanent teeth erupted per stated age for these children, and for the remainder of the study group.

Results

The results of this investigation which are shown in Table 14 show that dental development was apparently slower in children who had been baptised than in those who had not.

Table 14 Comparison of dental development (mean number of permanent teeth erupted per stated age) in Christianized and non-Christianized children

Sex and Stated Age in Years	Christianized		Non-Christianized	
	N	Mean no. of permanent teeth erupted	N	Mean no. of permanent teeth erupted
BOYS 7-	2	11.25	10	13.96
8-	1	15.00	18	18.17
9-	3	14.00	33	20.77
10-	1	16.00	35	23.46
11-12	4	21.50	35	25.46
GIRLS 7-	-	-	10	18.02
8-	-	-	18	20-70
9-	1	14.00	27	22.08
10-	1	10.00	27	25.23
11-12	-	-	22	26.26

Discussion and Conclusions

Although the numbers in this final investigation were small the indication was that chronological age as recorded in school registers in rural Zambia could not be trusted, since there was an apparent tendency for age to be under-estimated. This would result in over-estimation of dental disease status

if stated age were to be adopted as the basis for data grouping. Furthermore, since there was no possible way of assessing the degree of under-statement of age in different schools, internal comparisons of disease status within the study group could not be carried out with confidence unless an alternative method of data grouping were adopted.

[iv] The data were therefore grouped according to maturation based on dental development, a system which has been used by Mansbridge (1956) and discussed by Barmes (1967). The selection of maturation groups was based on the findings of Akpata (1971) in Nigeria who reported that in age-certificated children eruption of permanent teeth showed bilaterality and equivalent manibular and maxillary teeth erupted within one year (except for central incisors where the difference was 1.2 years).

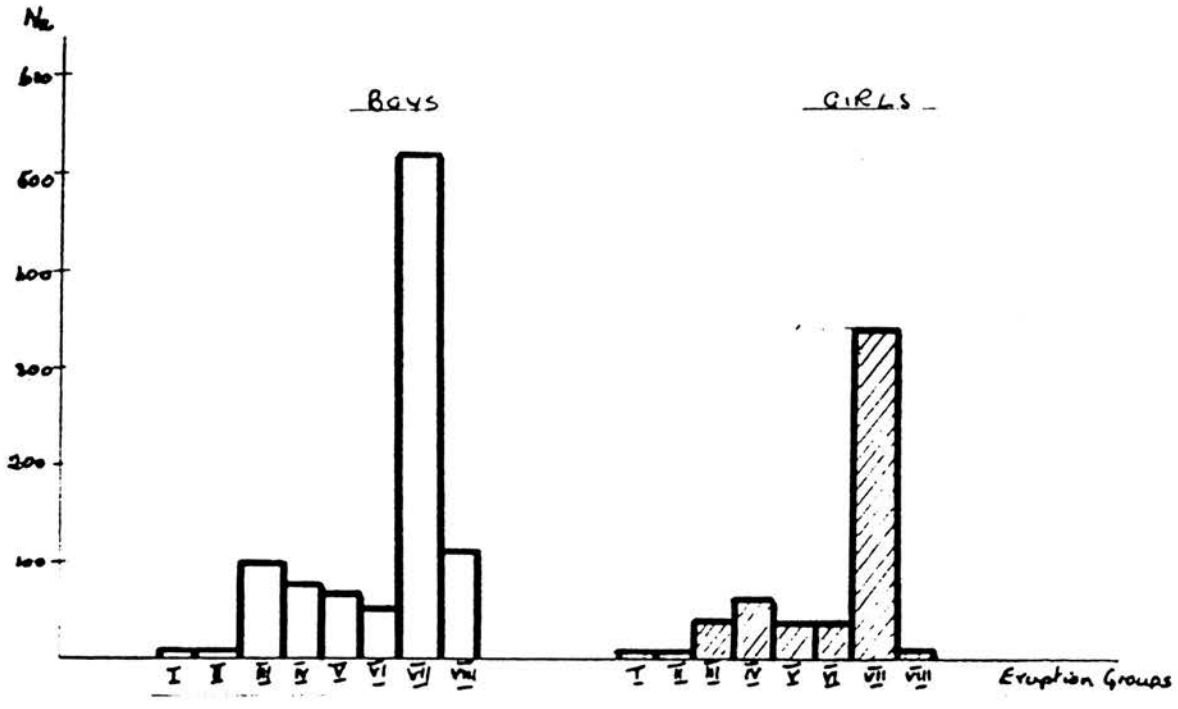
The grouping system adopted was based on the eruption of four teeth giving a total of eight 'eruption' or 'maturation' groups thus:

GROUP	I	0 - 4	permanent	teeth	erupted
"	II	5 - 8	"	"	"
"	III	9 - 12	"	"	"
"	IV	13 - 16	"	"	"
"	V	17 - 20	"	"	"
"	VI	21 - 24	"	"	"
"	VII	25 - 28	"	"	"
"	VIII	29 - 32	"	"	"

The modal distribution of deciduous and permanent teeth for these eruption groups is shown in Appendix IV, Tables 8 and 9. The numerical distribution of the study group by development, sex, tribe, school and boarding status is shown in Appendix IV, Tables 10 - 13.

As can be seen from Fig. 6

Figure 6 Distribution of the study group by sex and development

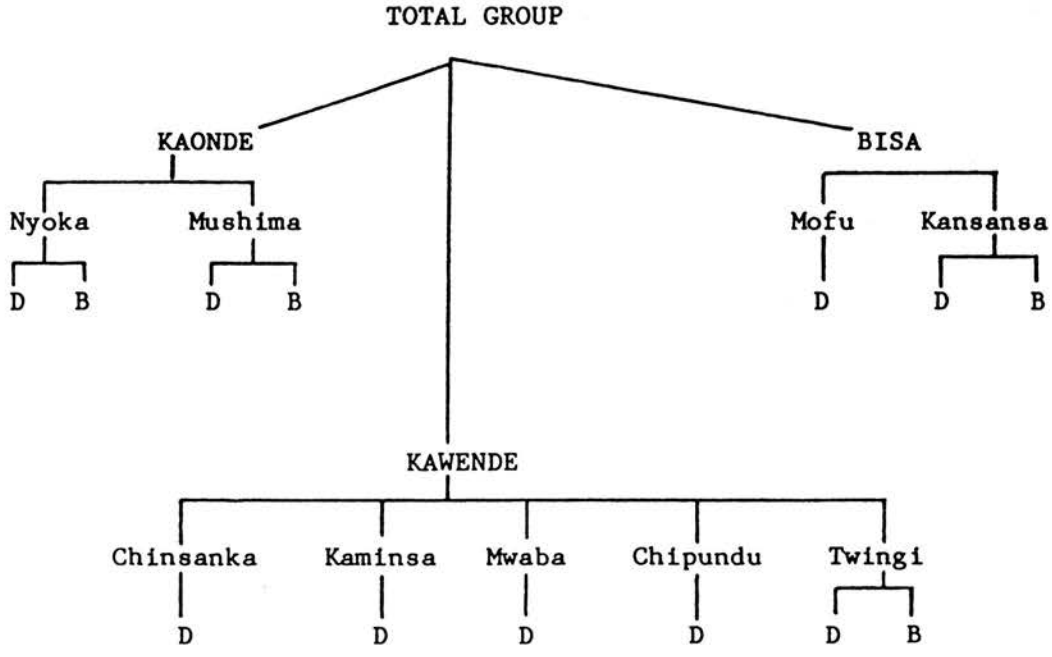


the majority of the study group (57 percent of the boys and 64 percent of the girls) fell into eruption group VII, i.e. with 25 - 28 permanent teeth present, and this was the position in all three tribes. Numbers were very small in eruption groups I and II, and among the girls also in eruption group VIII.

PART FIVE - ANALYTICAL METHODS

[i] Analytical procedures were based on the natural divisions of the study group, taking into account sex and development, into three tribal sub groups, themselves divided into nine school groups. Four schools could be further divided into day and boarding pupils thus:

Figure 7 Natural divisions of the study group



D = day pupils

B = boarding pupils

[ii] Group differences in prevalence of disease were tested using the χ^2 test with Yates' correction. These tests were carried out using a Hewlett Packard 97 calculator. When numerical requirements of the test could not be met Fisher's Exact Probability Test was applied.

Ranked qualitative data pertaining to oral hygiene status were tested non-parametrically using the Mann Whitney U test (Siegel 1956) which were performed manually.

The quantitative data pertaining to caries experience were tested using the Fisher's 't' tests and one way analysis of variance performed by the computer. Where othertests were applied in specific situations they have been described in the text.

[iii] A conservative approach was applied to interpretation of the findings, with greater weight being given to the consistency with which group differences were found rather than numerical expression. Only when interesting differences were both clinically and statistically consistent at probability values of <0.01 or < 0.001 were they regarded as important.

DISCUSSION

[i] -administrative methods

The administrative methods were in general unexceptional. The lack of a structured pilot study was offset by the time which was available early in the exercise when attention could be given to planning training and calibration with some experience of the field conditions likely to be encountered during the study. The availability of children at Mushingashi School for repeated examination, and the co-operation of the teacher in allowing this was a considerable asset. Reproducibility in this exercise was generally good.

Viewed with hindsight, the assessment of skeletal malocclusion might have been abandoned at an early stage, since the results from Mushingashi were not encouraging. The choice of the P.D.I. at this stage reflected the inexperience of the examiner, for even then it was becoming apparent that this index was more suitable for clinical trials than for basic field surveys (Davies 1968).

Circumstances dictated the use of standardised blunt probes but the degree of technical support which allowed this procedure was an unusual asset in a developing country. The use of blunt probes was then, and still is, a departure from W.H.O. recommendations (W.H.O. 1962, 1977) but it has now become a recognised procedure in dental health surveys (Gray, Todd, Slack and Bulman 1970). Downer and Mullane (1975)

have shown that, as the bench examination of extracted teeth indicated, the use of sharp probes may lead to false positive diagnoses of caries. Thus what was the only practical course at the time gives added credibility to the caries diagnosis.

It has been shown how standardisation of the examination conditions was possible despite the primitive facilities, which supports the views of Akinosi (1979) and Franklin (1979) who have both stated that lack of facilities should not be regarded as a barrier to dental epidemiological study in Africa.

[ii] - examination regime

With the advent of the 'pathfinder' approach (W.H.O. 1977) the examination of all available children might now be regarded as unnecessary from the standpoint of data gathering only, but with the service commitment and sensitivity of co-operation it was the only course. It is possible that the dual role of the examiner may have introduced bias as Pickles (1970) found, but this should only have occurred if at all, in subjective basic assessment of periodontal disease.

The use of the OHI/S was probably far more sensitive than the situation warranted, but it does allow the computation of mouth prevalence of debris and calculus which is now the recommended procedure (W.H.O. 1977). The data from Zambia would have been more informative had all the clinical observations been transcribed rather than the computed scores for each individual.

The method used for the basic assessment of periodontal disease has been criticised as being insensitive in the recording of destructive lesions (Wong 1965) and for involving a large element of inter-examiner error (Davies Horowitz and Wada 1974). However as these latter authors found the intra-examiner error was acceptable and the method would appear to be appropriate.

In retrospect the clinical examination methods could be criticised for being over ambitious. Some of the fault lies in the recommendations of the time and some in the inexperience of the examiner. Time was wasted which could have been better used in establishing a larger study group. However the majority of the techniques were adequately robust to give confidence in the clinical findings.

[iii] - supplementary exercises

It was unfortunate that the attempt to measure heights and weights was fruitless as the question of development in relation to stated age was germane to data handling. The investigations into the fluoride content of the drinking water, however, provided valuable additional information.

[iv] - data handling

Although the process of transcription was carefully undertaken, it would have been better if all the raw data had been transcribed in full. This would have allowed greater

flexibility in the retrospective analysis.

Given the rapid advances in computer technology in recent years, the manual approach to tabulation and data handling may seem unnecessarily laborious, but even now manual handling is recognised as being appropriate if the subject is relatively simple and the process to be undertaken only once (Anderson 1981). It demonstrates that lack of computer facilities in developing countries need not be regarded as a barrier to the preparation of reports. However the later use of a computer provided the ability to apply statistical testing of a higher order to the caries data which could not have been undertaken manually.

The close attention given to the potential inaccuracy of stated age in rural Zambia is unique in the literature from Africa. It may be that the social conditions were more extreme than had been encountered by other observers and the situation was therefore more obvious. The necessity to group the data by maturation rather than chronological age severely limits the value of the clinical findings in the broader context.

[v] - analytical methods

The analytical methods made full use of the natural sub-divisions of the study group which offered considerable scope for group comparisons. Statistical testing of group differences took into account the levels of measurement and

the numerical size of the groups under consideration and was in accord with standard procedures.

[vi] - Conclusion

It was shown in Chapter Three that the social and physical conditions in rural Zambia were not altogether favourable for dental epidemiological study. The methodology applied in these unpropitious circumstances was basic, robust and in accord with recommended procedures of the time in order that the reporting of clinical findings might be reliable. Some valuable information was lost through transcription. Individuality in data grouping was dictated by the lack of confidence in statements of age. A conservative approach was maintained throughout in order that meaningful interpretation could be made of the clinical findings.

CHAPTER FIVE - FINDINGS

Caries in deciduous teeth

Caries in permanent teeth

Periodontal disease

Disorders of mucosa teeth and bone, and dentofacial anomalies

Chapter Five

FINDINGS

PART ONE - CARIES IN DECIDUOUS TEETH

[1] Of the 1,440 children in the study group, 553 (38%) were in the mixed dentition phase. Of these 211 had carious lesions in deciduous teeth giving an overall prevalence of 38%. The mean number of decayed deciduous teeth per child (mean dt/child) for the mixed dentition group was 0.92.

Caries prevalence and experience in the deciduous dentition is shown in table 15 by sex and development, excluding those children in eruption groups I and II where the numbers were very small.

Table 15 Caries prevalence and experience in deciduous teeth by sex and development*

Er. Grp.	BOYS				GIRLS			
	N	% with caries	mean dt/ child	(S.E.)	N	% with caries	mean dt/ child	(S.E.)
III	89	40.5	1.22	(0.21)	39	43.6	1.13	(0.29)
IV	64	48.4	1.36	(0.24)	58	48.3	1.29	(0.24)
V	62	38.7	0.82	(0.19)	36	33.3	0.81	(0.23)
VI	43	37.2	0.74	(0.20)	35	20.0	0.37	(0.15)
VII	54	25.9	0.46	(0.13)	57	38.6	0.54	(0.13)
TOTAL	**312**	**38.8**	**0.97**	**(0.09)**	**225**	**38.2**	**0.87**	**(0.10)**

* Taken from Appendix V, Table 1.

Involvement was greatest in eruption Group IV and declined thereafter with exfoliation. Caries experience was consistently slightly higher in boys than in girls but the differences were not found to exceed even 95% confidence limits.

In order to investigate the possibility of geographical variation the data for the three tribes were separated. Eruption groups III and IV were then selected as having the most deciduous teeth available for examination. The results of this investigation are shown in Table 16.

Table 16 Caries experience in deciduous teeth (mean DT/child) by sex and tribe in eruption groups III and IV *

Er Group and tribe	BOYS			GIRLS			TOTAL		
	N	Mean dt / child	(S.E.)	N	Mean dt / child	(S.E.)	N	Mean dt / child	(S.E.)
III (KAONDE	15	1.33	(0.54)	4	0.25	(0.25)	19	1.10	(0.44)
III (KAWENDE	62	1.31	(0.26)	23	1.09	(0.34)	85	1.25	(0.21)
III (BISA	12	0.67	(0.50)	12	1.50	(0.60)	24	1.08	(0.42)
IV (KAONDE	10	1.30	(0.34)	9	1.56	(0.71)	19	1.42	(0.37)
IV (KAWENDE	40	1.25	(0.31)	41	1.32	(0.29)	81	1.28	(0.21)
IV (BISA	14	1.71	(0.58)	8	0.88	(0.61)	22	1.41	(0.21)

* Taken from Appendix V, Table 2

No consistent pattern of tribal variation was apparent.

(ii) Carious lesions were predominantly present in deciduous molars. Very few incisors were available for examination (Appendix IV, Table 11) and none were found to be attacked. Three children only presented with involvement of canines, one with bilateral and two with unilateral maxillary lesions. The distribution of caries in deciduous molars is shown in Table 17.

Table 17 Distribution of caries in deciduous molars

	BOYS			GIRLS		
	No. Teeth Present	No. Decayed	%	No. Teeth Present	No. Decayed	%
Upper:						
1st Molar	351	63	17.9	239	40	16.7
2nd	548	91	16.6	321	49	15.3
Lower:						
1st	366	66	18.0	193	46	23.8
2nd	466	91	19.5	312	63	20.2

The majority (58 percent) of the decayed deciduous teeth had occlusal lesions only, 14 percent had interstitial lesions and 27 percent were grossly destroyed. Although the df index did not include a registration of teeth indicated for extraction this information was available from the clinical records. Since endodontics and major restorations were not practicable the criteria for extraction were low. The mean number of deciduous teeth indicated for extraction was 0.26 'i' teeth per child in both sexes distributed as shown in Table 18.

Table 18 Mean number of deciduous teeth indicated for extraction (i teeth) per child by sex and development

	BOYS			GIRLS		
Er. Grp.	**N**	**No. 'i' teeth**	**Mean 'i' teeth/child**	**N**	**No. 'i' teeth**	**Mean 'i' teeth/child**
III	89	13	0.15	39	0	0
IV	64	16	0.25	58	13	0.22
V	62	14	0.23	36	13	0.36
VI	43	19	0.44	35	9	0.26
VII	54	20	0.37	57	23	0.40
TOTAL	**312**	**82**	**0.26**	**225**	**58**	**0.26**

PART TWO - CARIES IN PERMANENT TEETH

A. CARIES EXPERIENCE

(i) In the total study group of 1,440 children, 685 (48%) were found to have caries in permanent teeth. In all 2,198 teeth had been attacked giving a mean value of 1.53 decayed permanent teeth per child (mean DT/child). Classified according to the World Health Organisation (W.H.O. 1980a) which gives the following figures for 12 year-olds.

0	-	1.1	DT/child	-	Very low
1.2	-	2.6	DT/child	-	Low
2.7	-	4.4	DT/child	-	Moderate

the overall level of caries experience was 'low'.

(ii) Caries prevalence and experience in permanent teeth in relation to sex and development are shown in Table 19. Data for eruption groups I and II have been excluded since numbers in these groups were very small.

Caries prevalence in the total group was higher in girls (52%) than in boys (45%), and more girls were affected in eruption groups IV, VI and VII. These differences did not exceed 99% confidence limits.

However, the difference in caries experience between the sexes with girls having a mean DT/child of 1.75 and boys 1.41 was significant at this level ($P < 0.01$).

Table 19 Caries prevalence and experience in permanent teeth by sex and development (total group excluding Er. Grps I and II)*

	BOYS				GIRLS			
Er Group	**N**	**% with caries**	**Mean DT / child**	**(S.E.)**	**N**	**% with caries**	**Mean DT / child**	**(S.E.)**
III	93	33.3	0.74	(0.13)	40	32.3	0.57	(0.16)
IV	71	35.2	0.73	(0.14)	59	51.7	1.14	(0.18)
V	62	33.9	0.73	(0.15)	37	32.4	0.78	(0.22)
VI	51	29.4	0.80	(0.24)	41	45.2	1.20	(0.26)
VII	521	52.0	1.79	(0.11)	336	57.4	2.17	(0.15)
VIII	106	43.4	1.30	(0.20)	7	71.4	2.00	(0.66)
TOTAL	**904**	**45.2**	**1.41****	**(0.07)**	**520**	**52.3**	**1.75****	**(0.11)**

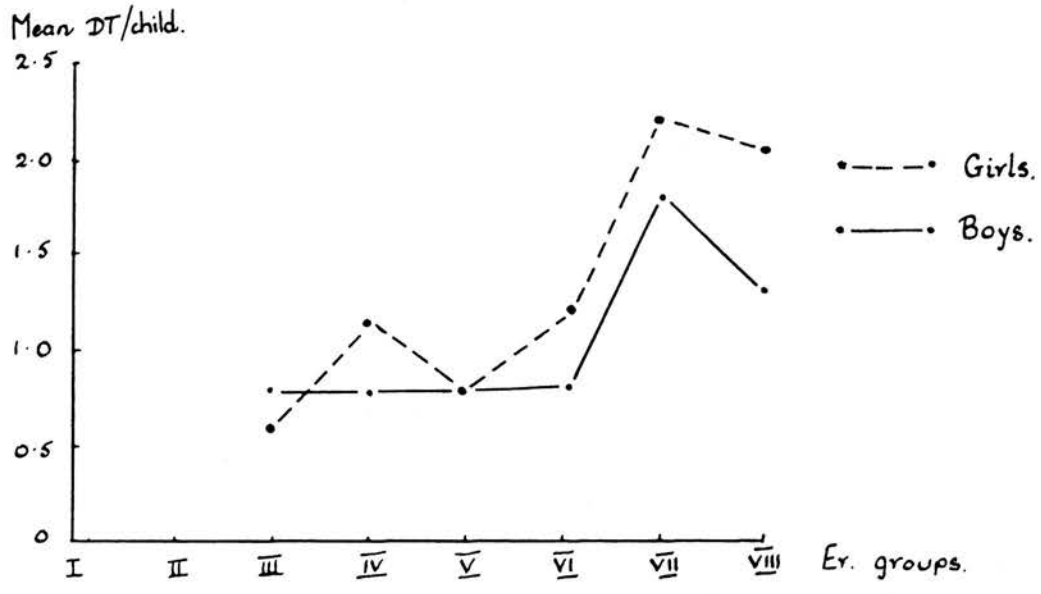
* Taken from Appendix V, Table 3

** Boys / Girls $P < 0.01$

On investigation,no further sex differences at this level were found in either developmental or tribal sub groups.

Caries experience increased with development in both sexes with a marked rise between Groups VI and VII, i.e. coinciding with the eruption of the second permanent molars. This is shown in Figure 8. Among the boys the rise from 1.20 mean DT/child in Group VI to 2.17 mean DT/child in Group VII was particularly striking ($P < 0.01$).

Figure 8 Permanent caries experience by sex and development



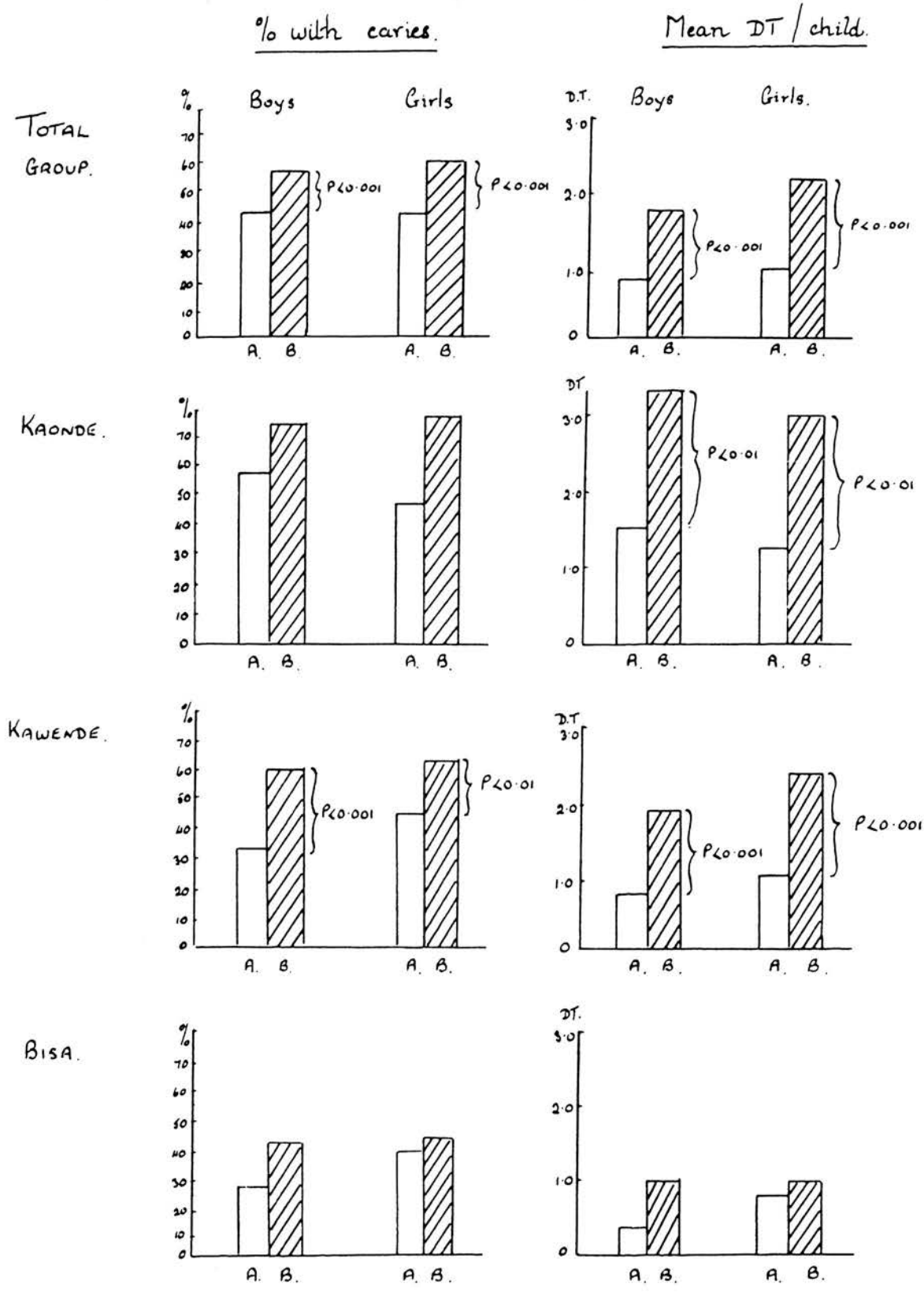
The effect of development on caries experience was more clearly demonstrated when the data were pooled into two maturation groups:

GROUP A = eruption groups I - VI

GROUP B = eruption groups VII and VIII

as shown in Figure 9. In the total group it can be seen that younger children had 'very low' caries experience while older ones had 'low'. This was also the situation within the Kawende tribe. In the Kaonde tribe the levels rose from 'low' in younger children to 'moderate' in older children. In the Bisa tribe the increases were less marked and remained within the 'very low' category.

Figure 9 Caries experience in permanent teeth by sex, development (Groups A and B) and tribe.



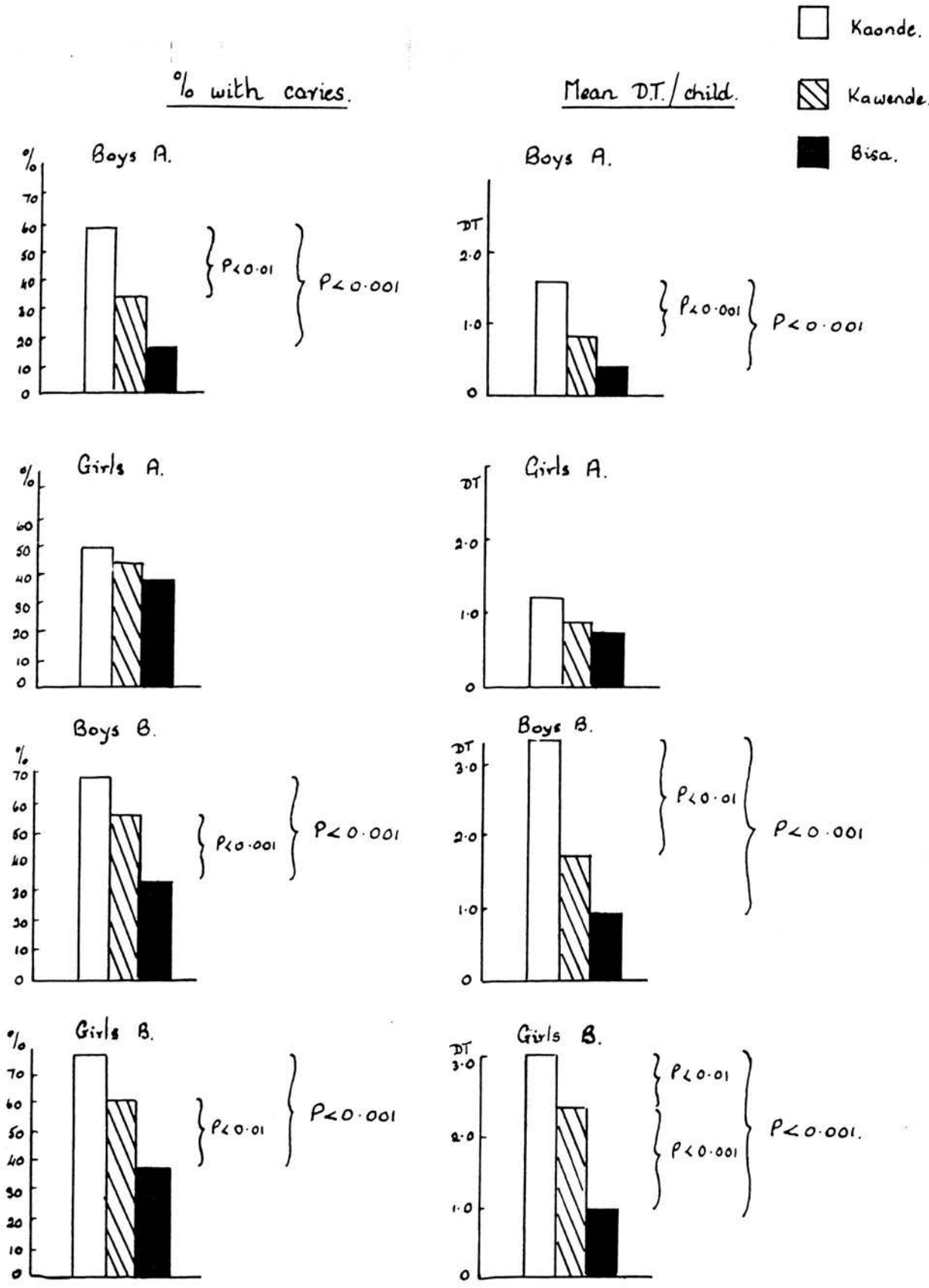
[iii] There was a clear and consistent pattern of tribal variation in caries experience with children of the Kaonde tribe most affected and those of the Bisa tribe least affected. Taking sex and development into account the figures are shown in table 20 for maturation groups A and B. One way analysis of variance revealed that this tribal variation was highly significant ($P < 0.001$) in both groups of boys and in older girls.

Table 20 Tribal variation in permanent caries experience

	KAONDE			KAWENDE			BISA			
	N	Mean DT / child	(S.E.)	N	Mean DT / child	(S.E.)	N	Mean DT / child	(S.E.)	P
BOYS A	44	1.52	(0.26)	197	0.66	(0.09)	47	0.32	(0.12)	<0.001
BOYS B	77	3.38	(0.39)	356	1.79	(0.12)	194	0.89	(0.13)	<0.001
GIRLS A	26	1.23	(0.29)	118	0.97	(0.13)	38	0.71	(0.19)	n.s.
GIRLS B	73	3.04	(0.33)	198	2.31	(0.20)	72	0.88	(0.18)	<0.001

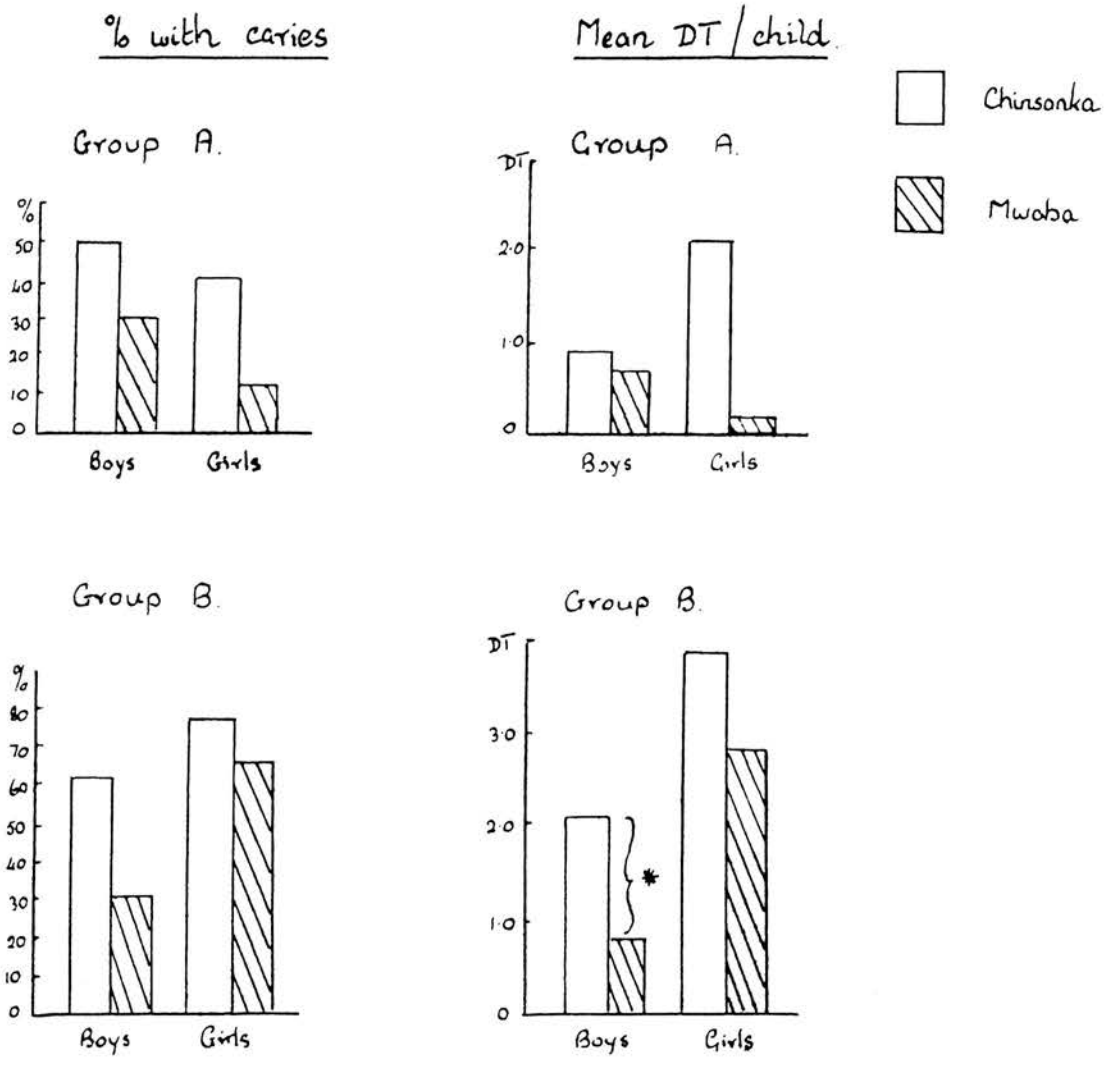
More detail of the tribal variation is given in Figure 10.

Figure 10 Tribal variation in caries experience by sex and development (Groups A and B)



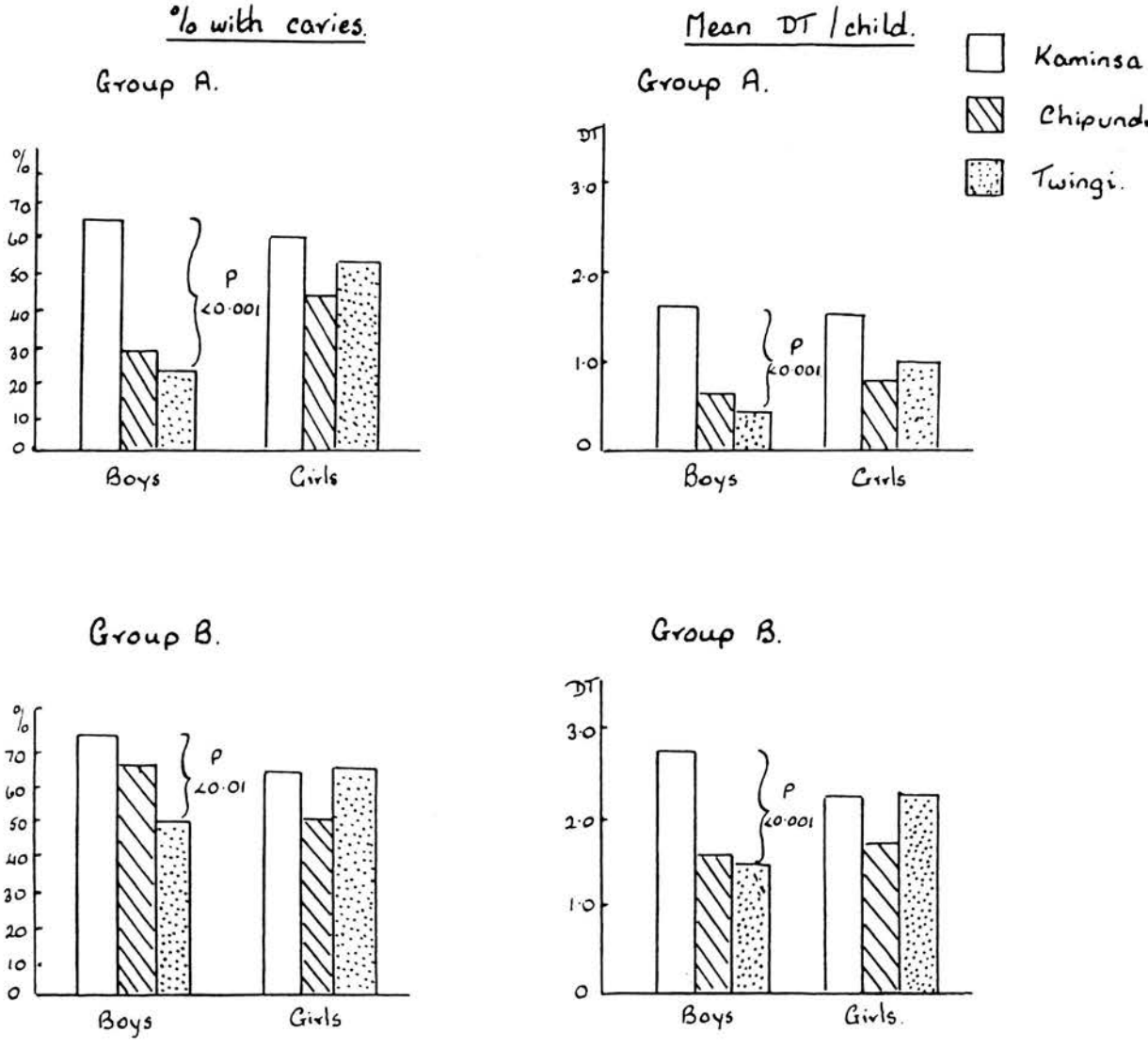
(iv) Analysis of the position within tribes revealed no significant variation in either the Kaonde or the Bisa tribes but a regional variation was present within the Kawende tribe. In the two lower primary schools Chinsanka and Mwaba, caries experience was generally higher in children attending Chinsanka, the more northerly of the two (Figure 11) with a significant difference ($P < 0.001$) in Group B boys.

Figure 11 Caries experience in permanent teeth in the two lower primary schools of the Kawende tribe



Among those Kawende children attending upper primary schools, no significant regional variation could be found among the girls, but in the boys the position was very striking, with again higher caries experience at the northern end of the peninsula (Figure 12).

Figure 12 Caries experience in permanent teeth in the three upper primary schools of the Kawende tribe



In order to examine the possibility of geographical variation in caries experience within the Kawende tribe more closely, the data were pooled for the two catchments indicated by the previous investigations thus:

Northern catchment	-	Chinsanka school
		Kaminsa "
Southern catchment	-	Mwaba "
		Chipundu "
		Twingi "

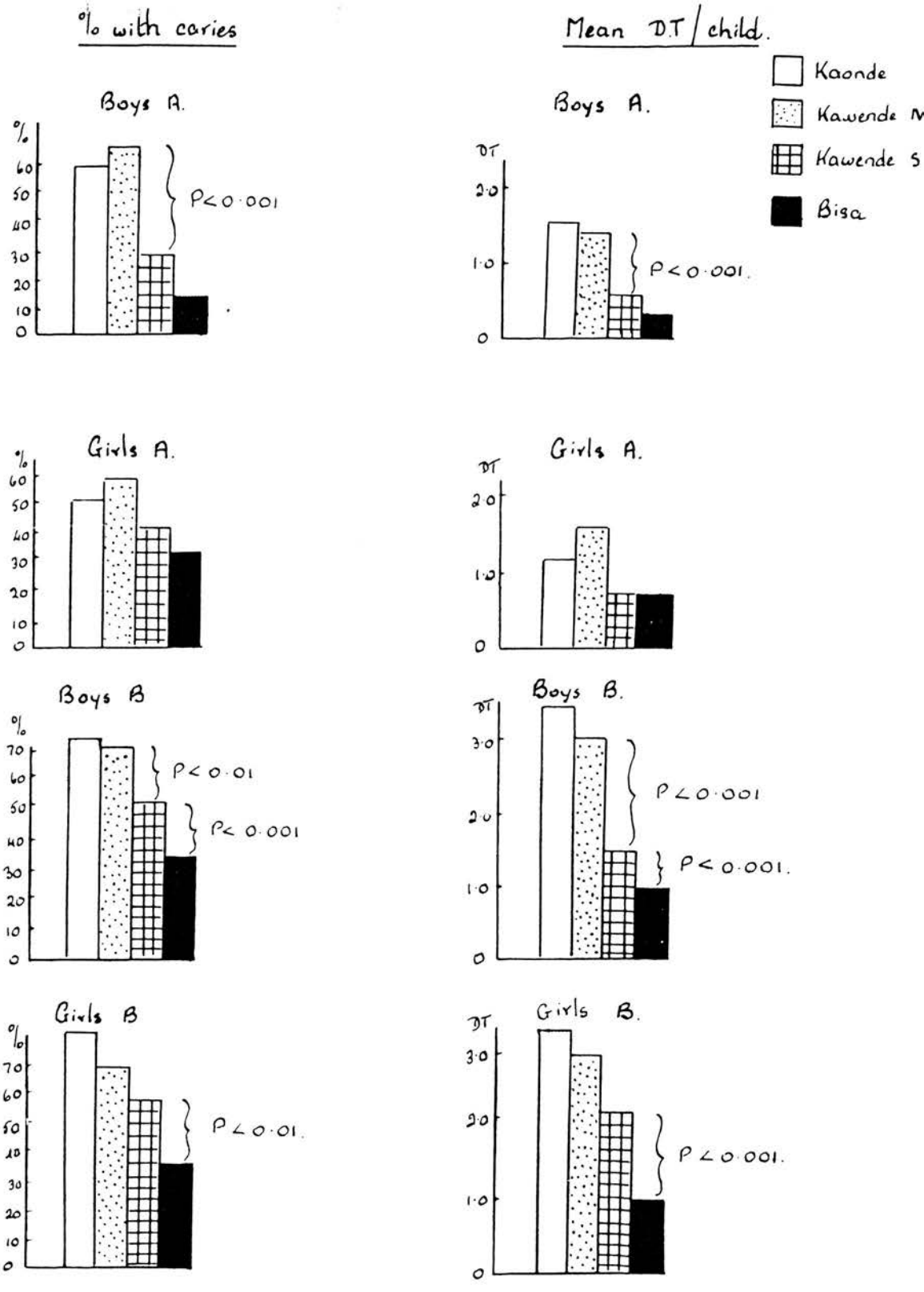
Comparison of caries experience between these two catchments as shown in table 21 showed consistently higher caries levels in the northern catchment with differences of $P < 0.001$ in both groups of boys.

Table 21 Comparison of caries experience in permanent teeth between the Northern and Southern catchments of the Kawende tribe

	NORTHERN			SOUTHERN			
	N	Mean DT Child	(S.E.)	N	Mean DT Child	(S.E.)	P
BOYS A	31	1.48	(0.27)	166	0.51	(0.08)	<0.001
BOYS B	130	2.48	(0.23)	226	1.39	(0.14)	<0.001
GIRLS A	26	1.61	(0.38)	92	0.78	(0.13)	<0.01
GIRLS B	64	2.72	(0.40)	134	2.12	(0.23)	n.s.

(v) It was therefore apparent that the situation was not that of a simple tribal variation in caries experience. Re-appraisal of the overall pattern with the Kawende tribe divided into the two catchments showed that caries experience in the northern catchment of the Kawende tribe was more akin to that found in children of the Kaonde tribe than it was to children of the same tribe living only a few miles away. This is shown in detail in Figure 13.

Figure 13 Tribal caries experience with the Kawende tribe divided into northern and southern catchments by sex and development (A and B)



B PERMANENT CARIES EXPERIENCE AND INDEPENDENT VARIABLES

Six independent variables had been identified during the field investigations -

consumption of refined foods

long term proximity to European influences

fluoride intake

oral cleanliness

school structure

traditional diet

[i] Availability of refined foods was low in all cases, but was least at Kansansa Island in the Bisa territory where caries experience was 'very low' to 'low' and in the Kaonde territory where caries experience was 'low' to 'moderate'. Within the Kaonde tribe caries experience was generally higher at the more remote Nyoka school where availability of refined foods had been non existant (Table 22).

Table 22 Caries experience in permanent teeth at Nyoka and Mushima schools

	NYOKA			MUSHIMA		
	N	Mean DT/child	(S.E.)	N	Mean DT/child	(S.E.)
BOYS A	22	1.88	(0.40)	22	1.18	(0.33)
BOYS B	32	4.03	(0.60)	45	2.91	(0.44)
GIRLS A	13	1.00	(0.39)	13	1.46	(0.43)
GIRLS B	45	3.22	(0.44)	28	2.75	(0.49)

No difference in the availability or consumption of refined foods was apparent between the northern and southern catchments of the Kapata peninsula.

(ii) Twingi school was the only one with long term proximity to European influences, but the caries experience there did not differ significantly from that at the other two schools in the southern catchment of the Kawende tribe (Table 23).

Table 23 Caries experience in permanent teeth in Mwaba, Chipundu and Twingi schools

		BOYS			GIRLS		
		N	Mean DT/child	(SE)	N	Mean DT/child	(SE)
A	MWABA	42	0.62	(0.18)	17	0.18	(0.13)
	CHIPUNDU	57	0.58	(0.17)	31	0.74	(0.19)
	TWINGI	67	0.37	(0.11)	44	1.05	(0.20)
B	MWABA	33	0.67	(0.22)	26	2.77	(0.61)
	CHIPUNDU	98	1.53	(0.19)	60	1.65	(0.29)
	TWINGI	95	1.49	(0.23)	48	2.35	(0.37)

(iii) Caries experience in permanent teeth did not correspond to the variation in fluoride content of the drinking water. This is shown in Table 24 for the older boys which were numerically the largest group and probably the most representative.

Table 24 Caries experience in older boys (Group B) in relation to the fluoride content of drinking water

Tribal Group or Sub-Group	Mean DT / child	(S.E.)	FI (ppm)
KAONDE	3.38	(0.39)	0 - 0.3
KAWENDE (north)	2.48	(0.23)	0 - 0.1
KAWENDE (south)	1.39	(0.14)	0 - 0.1
BISA	0.59	(0.13)	0

(iv) Caries experience in permanent teeth did not correspond to variation in oral cleanliness (Table 25). On the contrary, girls had generally better oral hygiene status than boys, and the children of the Kaonde tribe who had the highest caries experience also had consistently cleaner mouths than those of the other tribes.

Table 25 Caries experience in relation to oral cleanliness by sex and development (A and B)

	B O Y S				G I R L S			
	N	Mean DT /child	(S.E.)	Median* OHI/S score	N	Mean DT /child	(S.E.)	Median* OHI/S score
GROUP A								
KAONDE	44	1.52	(0.26)	1.45	26	1.23	(0.29)	0.40
KAWENDE N.	31	1.48	(0.27)	2.30	26	1.61	(0.38)	2.65
KAWENDE S.	166	0.51	(0.08)	2.20	92	0.78	(0.13)	2.00
BISA	47	0.32	(0.12)	2.80	38	0.71	(0.18)	2.10
GROUP B								
KAONDE	77	3.38	(0.39	2.00	73	3.04	(0.33)	1.00
KAWENDE N.	130	2.48	(0.23)	2.50	64	2.72	(0.40)	2.15
KAWENDE S.	226	1.39	(0.14)	2.60	134	2.12	(0.23)	2.15
BISA	194	0.89	(0.13)	2.70	72	0.88	(0.18)	2.70

* Taken from Appendix V, Table 6

[v] No differences exceeding 99 percent confidence limits existed in caries experience between day and boarding pupils at the four boarding schools (Table 26)

Table 26 Caries experience in permanent teeth in day and boarding pupils*

			DAY			BOARDING		
			N	Mean DT /child	(S.E.)	N	Mean DT /child	(S.E.)
NYOKA	BOYS	A	7	1.71	(0.64)	15	1.93	(0.52)
		B	12	3.92	(1.05)	20	4.10	(0.22)
	GIRLS	A	8	0.88	(0.44)	5	1.20	(0.80)
		B	29	3.10	(0.56)	16	3.44	(0.78)
MUSHIMA	BOYS	A	14	1.21	(0.44)	8	1.13	(0.56)
		B	22	3.09	(0.85)	23	2.74	(0.60)
	GIRLS	A	6	1.83	(0.59)	7	1.14	(0.63)
		B	13	2.54	(0.63)	15	2.93	(0.75)
TWINGI	BOYS	A	67	0.37	(0.11)	-	-	
		B	37	1.81	(0.51)	58	1.29	(0.17)
	GIRLS	A	23	0.91	(0.24)	21	1.19	(0.34)
		B	8	2.75	(0.62)	40	2.28	(0.47)
KANSANSA	BOYS	A	4	0.25	(0.25)	7	0	-
		B	15	0.93	(0.46)	33	0.82	(0.26)
	GIRLS	A	4	1.50	(0.96)	3	1.00	(1.00)
		B	6	1.50	(0.42)	12	1.33	(0.68)

* From Appendix V, Tables 5 and 7

[vi] Three aspects of the traditional diet were identified namely:

the carbohydrate staple

the apparent consumption of fresh protein

possible consumption of wild honey

The caries experience in older boys in relation to the carbohydrate staples of maize and cassava is shown in Table 27.

Table 27 Caries experience in permanent teeth of older boys (Group B) in relation to the carbohydrate staple

Tribal Group or Sub-Group	Mean DT/child	Staple
KAONDE	3.38 (moderate)	Maize only
KAWENDE N.	2.48 (low)	Cassava plus Maize
KAWENDE S.	1.39 (low)	Cassava only
BISA	0.59 (very low)	Cassava only

This table shows that caries experience was highest where maize constituted the whole of the carbohydrate staple, i.e. in children of the Kaonde tribe. In children of the Kawende tribe the caries experience in those whose diet included an element of maize was nearly double that of those who consumed only cassava. Caries experience was very low in the more remote Bisa tribe where only cassava was consumed.

Caries experience in relation to the apparent consumption of fresh protein is shown in Table 28.

Table 28 Caries experience in permanent teeth in older boys (Group B) in relation to the apparent availability and consumption of fresh Protein

Tribal Group or Sub-Group	Mean DT/child	Protein
KAONDE	3.38	No fresh fish
KAWENDE N.	2.48	No fresh fish
KAWENDE S.	1.39	Some fresh fish all year
BISA	0.59	Fresh fish part of the year Ground nut oil

Wild honey was only available in the Brachystegia woodlands of the Kaonde territory where caries experience was consistently higher than in the other tribal groups and sub-groups.

C. DISTRIBUTION, SITE, AND SEVERITY

[i] The detailed distributions of the proportions of erupted permanent teeth attacked by caries are given in Appendix V, Tables 8 and 9. The burden of carious attack was in molar teeth as shown in Table 29 for the children in eruption group VII.

Table 29 The proportion of erupted permanent molars with caries in children of eruption group VII

	% of Erupted Teeth with Caries*	
TOOTH	**BOYS**	**GIRLS**
Upper 1st Molar	12.6	18.0
Upper 2nd Molar	14.8	20.3
Lower 1st Molar	24.0	26.5
Lower 2nd Molar	28.7	33.9

* From Appendix V, Table 8.

More lower molars were affected than upper molars and second molars were more affected than first molars in both the maxilla and the mandible. This pattern was repeated in all four tribal groups and sub groups. Less than 6 percent of premolars were affected while canines and incisors were only very slightly involved.

A paired comparison of carious involvement in first and second molars in children of eruption group VII, applying

the formula of Fleiss and Everitt (1971) showed that at this stage of development the differences between attack in first and second molars exceeded 99 percent confidence limits only in the mandibular molars of boys.

Table 30 Paired comparison of caries in first and second permanent molars in children of eruption group VII (Summarised from the 3 x 3 tables)

CATEGORY**		A	B	C	D	χ^2 BC DF =2	P
Boys:	Uppers	388	41	44	48	6.78	n.s.
	Lowers	289	55	79	98	11.61	< 0.01
Girls:	Uppers	222	33	33	48	6.94	n.s.
	Lowers	156	41	64	75	8.00	n.s.

** Category A = number of children with no carious molars

Category B = number of children with 1 or 2 carious first molars, no carious second molars

Category C = number of children with 1 or 2 carious second molars, no carious first molars

Category D = number of children with at least 1 carious first molar and 1 carious second molar

[ii] The majority (96 percent) of all carious permanent teeth had lesions in the occlusal surfaces only. There were very few interproximal or cervical cavities. Only 0.5 percent of decayed teeth were diagnosed as having multiple lesions (Table 31).

Table 31 Site of carious lesions in permanent teeth

	BOYS		GIRLS		TOTAL	
	No. of teeth	**%**	**No. of teeth**	**%**	**No. of teeth**	**%**
Occlusal lesions only	1,238	96.5	880	96.2	2,118	96.4
Interproximal lesions only	24	1.9	27	3.0	51	2.3
Cervical lesions only	14	1.1	4	0.4	18	0.8
More than 1 lesion	7	0.6	4	0.4	11	0.5
No. of D. teeth	**1,283**		**915**		**2,198**	

[iii] Only 35 children in the total study group (2.4 percent) had permanent teeth indicated for extraction and the proportions were similar in both sexes (boys 2.6 percent, girls 2.1 percent). The total number of teeth indicated for extraction was 42 giving an overall mean value of 0.03 'I' teeth per child. Although amongst the boys the mean value of 'I' teeth was highest in the Kaonde tribe, this did not occur amongst the girls, (Table 32).

Table 32 Mean number of permanent teeth indicated for extraction (I) per child by sex and tribe (Kaonde, Kawende north, Kawende south, Bisa)

	N	No with 'I' teeth	%	No. of 'I' teeth	Mean 'I' teeth per Child
BOYS					
Kaonde	121	5	4.1	6	0.05
Kawende (north)	161	4	2.5	4	0.02
Kawende (south)	392	9	2.3	9	0.02
Bisa	241	6	2.5	6	0.02
TOTAL:	**915**	**24**	**2.6**	**25**	**0.03**
GIRLS					
Kaonde	99	2	2.0	3	0.03
Kawende (north)	90	1	1.1	1	0.01
Kawende (south)	226	5	2.2	7	0.03
Bisa	110	3	2.7	6	0.05
TOTAL:	**525**	**11**	**2.1**	**17**	**0.03**

As can be seen from Table 33, half of the teeth indicated for extraction were lower first permanent molars. The other 21 'I' teeth were of six different tooth types.

Table 33 Distribution of permanent teeth indicated for extraction (I) by tooth type expressed as a percentage of the total number of I teeth

Tooth	No. 'I'	% of Total 'I' Teeth
UPPER 1st Molar	7	16.7
LOWER 1st Molar	21	50.0
UPPER 2nd Molar	2	4.8
LOWER 2nd Molar	4	9.5
UPPER 1st Premolar	6	14.3
LOWER 1st Premolar	1	2.4
UPPER Lateral Incisor	1	2.4
TOTAL:	42	

PART THREE - PERIODONTAL DISEASE

A. PERIODONTAL DISEASE STATUS

[i] The distribution of periodontal disease in terms of mouth prevalence is shown in Table 34. The overall prevalence of 55percent of children affected was 'high' (W.H.O. 1980a)*.

Table 34 Mouth Prevalence of Periodontal Disease, Gingivitis and Pocketing**

	BOYS				GIRLS			
ER Group	N	% Intense Gingivitis	% Pocketing	% Perio Disease	N	% Intense Gingivitis	% Pocketing	% Perio Disease
I	4	0	50.0	50.0	2	0	0	0
II	7	57.1	14.3	71.4	3	0	0	0
III	93	31.2	10.7	41.9	40	42.5	0	42.5
IV	71	46.5	12.7	59.2	59	27.1	10.2	37.3
V	62	38.7	8.1	46.8	37	37.8	13.5	51.4
VI	51	33.3	9.8	43.1	41	41.5	2.4	43.9
VII	521	44.8	20.2	64.9	336	39.0	8.9	47.9
VIII	106	60.4	14.2	74.9	7	57.1	0	57.1
	915	**44.2**	**16.6**	**60.8**	**525**	**37.9**	**8.0**	**45.9**

** from Appendix V, Tables 10 - 12

Of those with periodontal disease, the majority (76 percent) had gingivitis alone, but 194 children already showed signs of destructive pocketing.

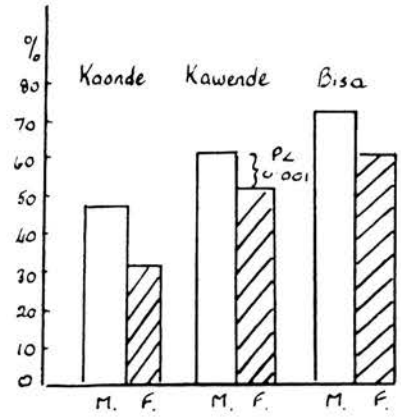
* (Low 0 - 20%) (Moderate 21 - 50%) (High 51 - 100%) W.H.O. (1980a)

[ii] Prevalence was higher in boys than in girls in terms of total disease ($P < 0.001$) and pocketing ($P < 0.001$). Differences between the sexes were consistent in all three tribal groups. Differences in gingivitis alone did not exceed 99 percent confidence limits but differences in pocketing were significant in the Kawende tribe ($P < 0.001$) (figure 14).

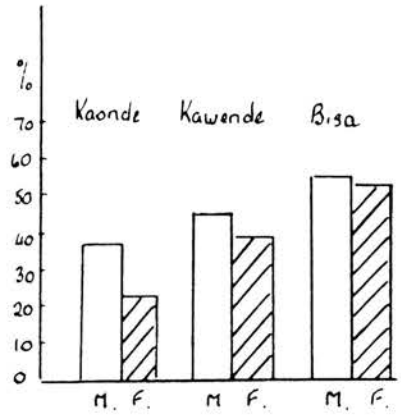
The tendency of higher periodontal disease experience to be found among the boys was continued to some extent in the schools although much of the statistical significance was lost through sub-division. Higher total disease experience in boys was found in seven out of nine schools, higher prevalence of gingivitis in five schools and higher prevalence of periodontal pocketing again in seven out of nine schools. The sex differences were most marked in the children attending Mushima school in the Kaonde tribal territory (Figure 15), and at Twingi school in the Kawende tribe.

Figure 14 Mouth Prevalence of Periodontal Disease, Gingivitis and Pocketing by Sex and Tribe*

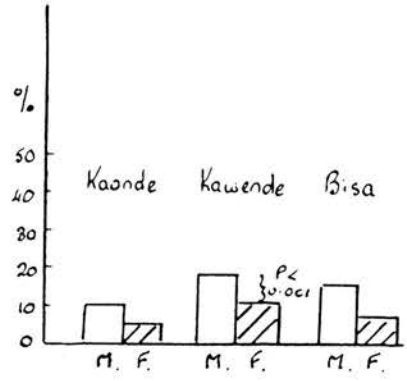
a) % Periodontal disease



b) % Intense gingivitis



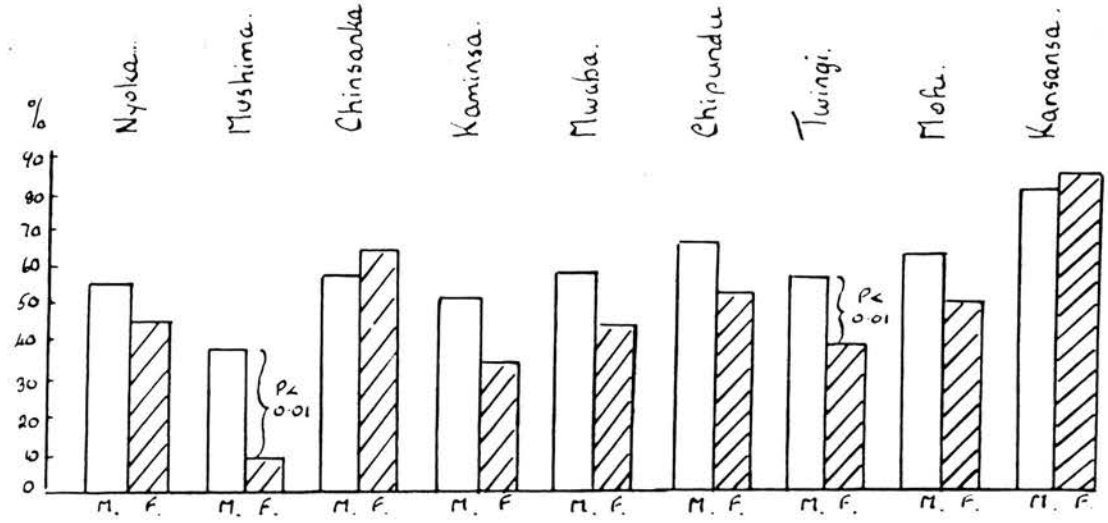
c) % Periodontal pocketing



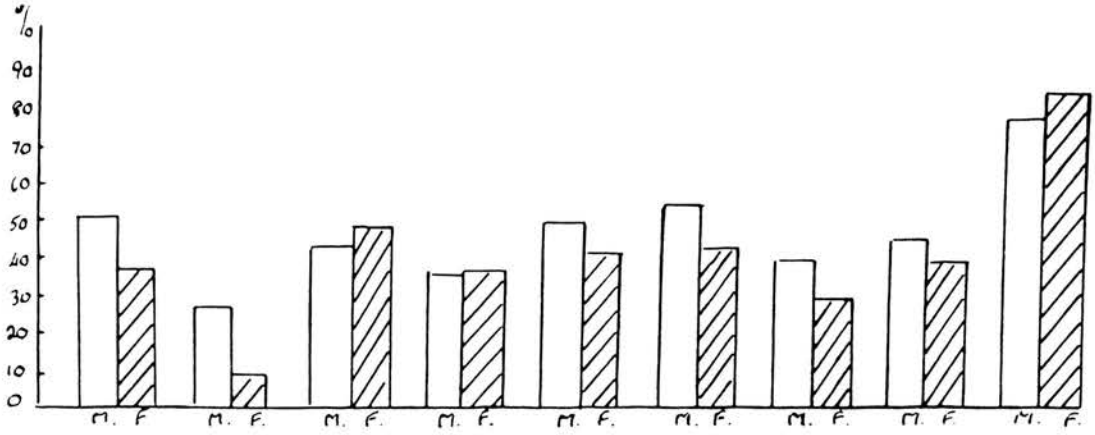
* from Appendix V, Tables 10 - 12

Figure 15 Mouth Prevalence of Periodontal Disease, Gingivitis and Pocketing by Sex and School*

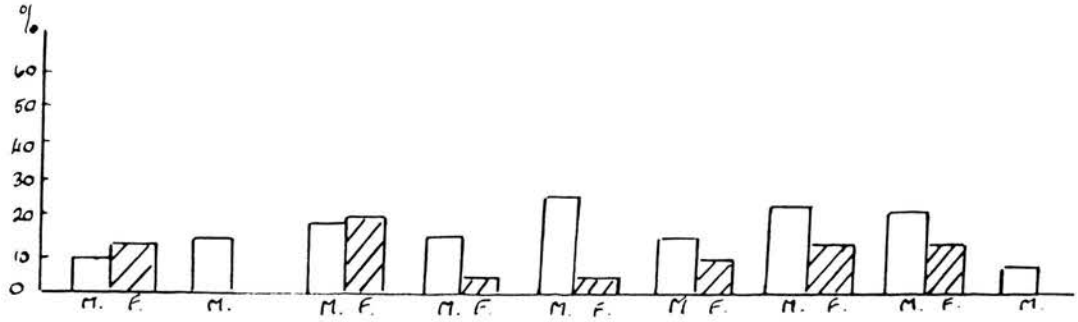
a) % Periodontal disease



b) % Intense gingivitis



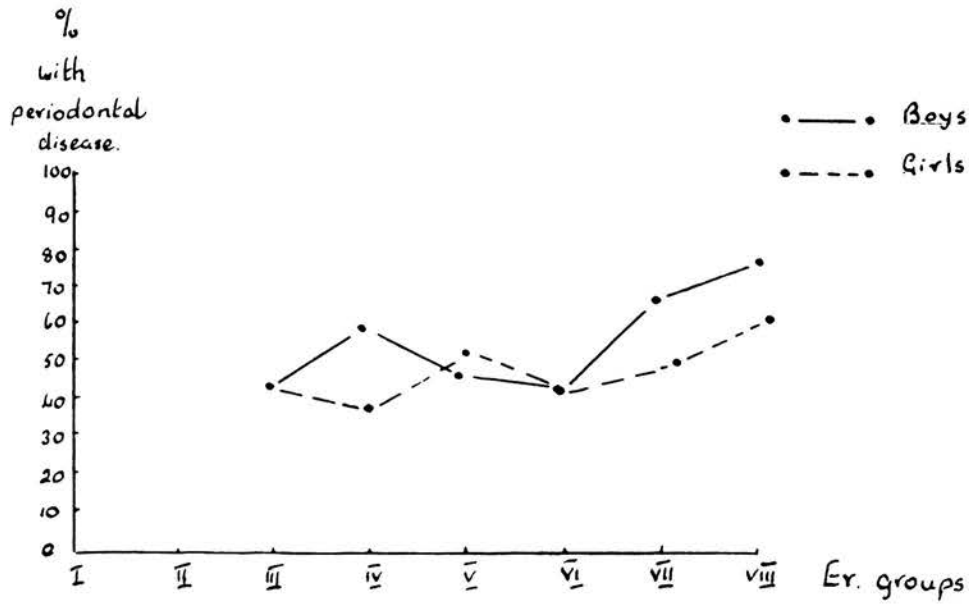
c) % Periodontal pocketing



* from Appendix V, Tables 10 - 12.

(iii) Prevalence of periodontal disease increased with development in both sexes. The increase was more marked among the boys (Figure 16).

Figure 16 Mouth Prevalence of Periodontal Disease by Sex and Development

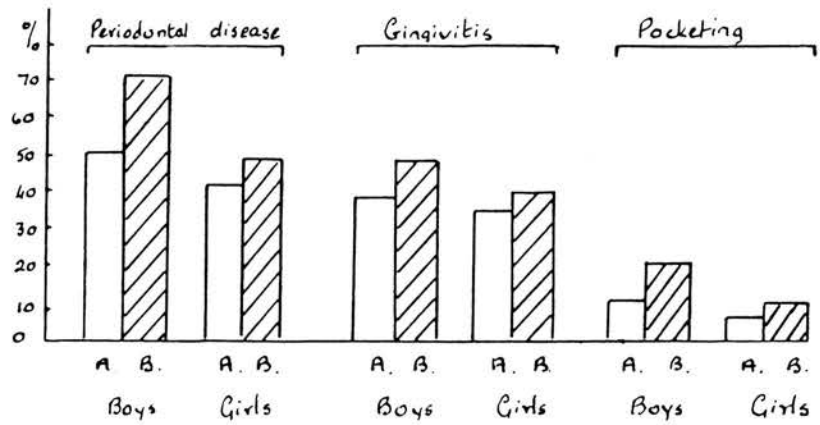


The effects of development were more clearly seen when the data were pooled as before into:

Group	A	eruption Groups I - VI
Group	B	eruption Groups VII and VIII

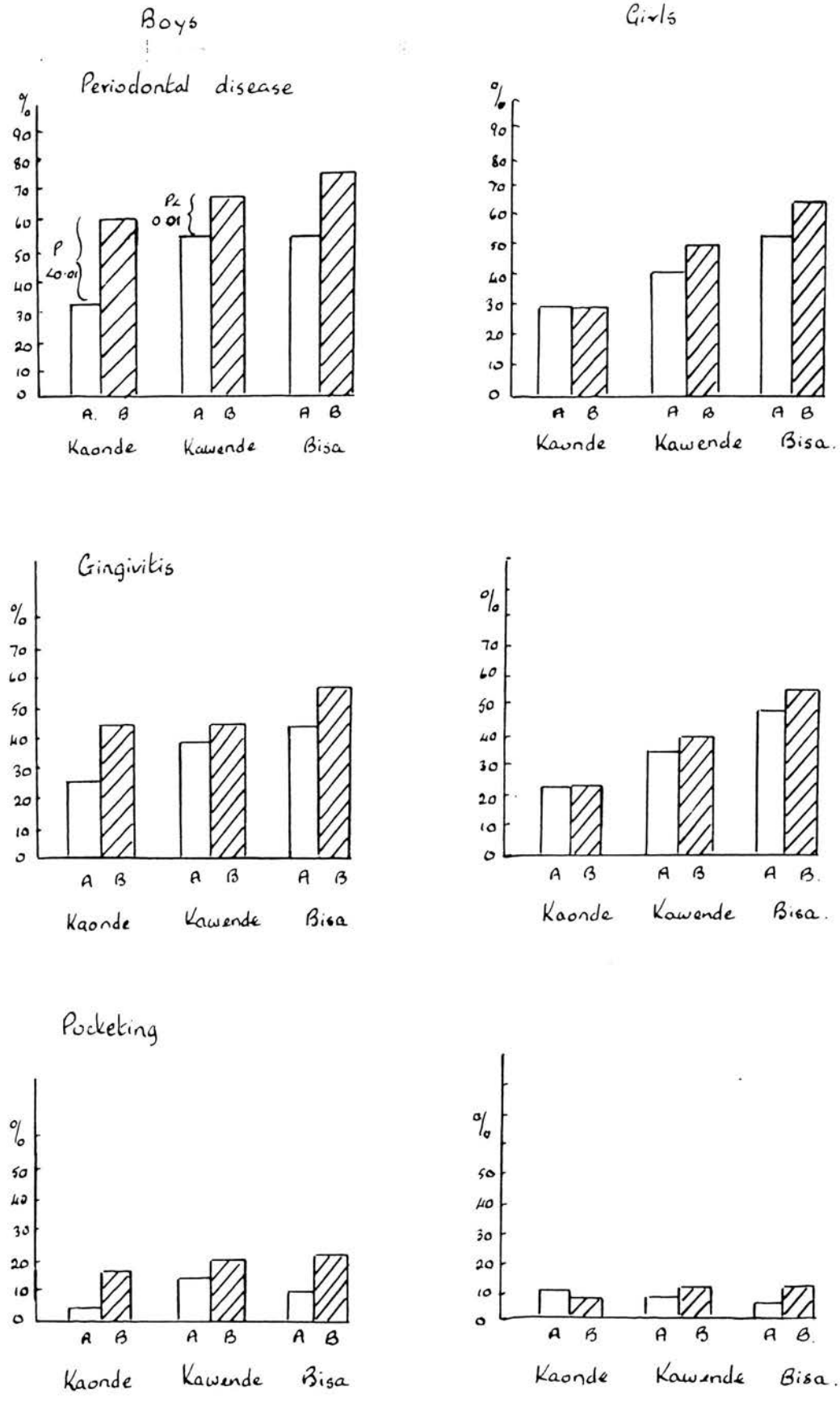
as shown in Figure 17.

Figure 17 Mouth Prevalence of Periodontal Disease, Gingivitis and Pocketing by Sex and Development (Groups A and B)



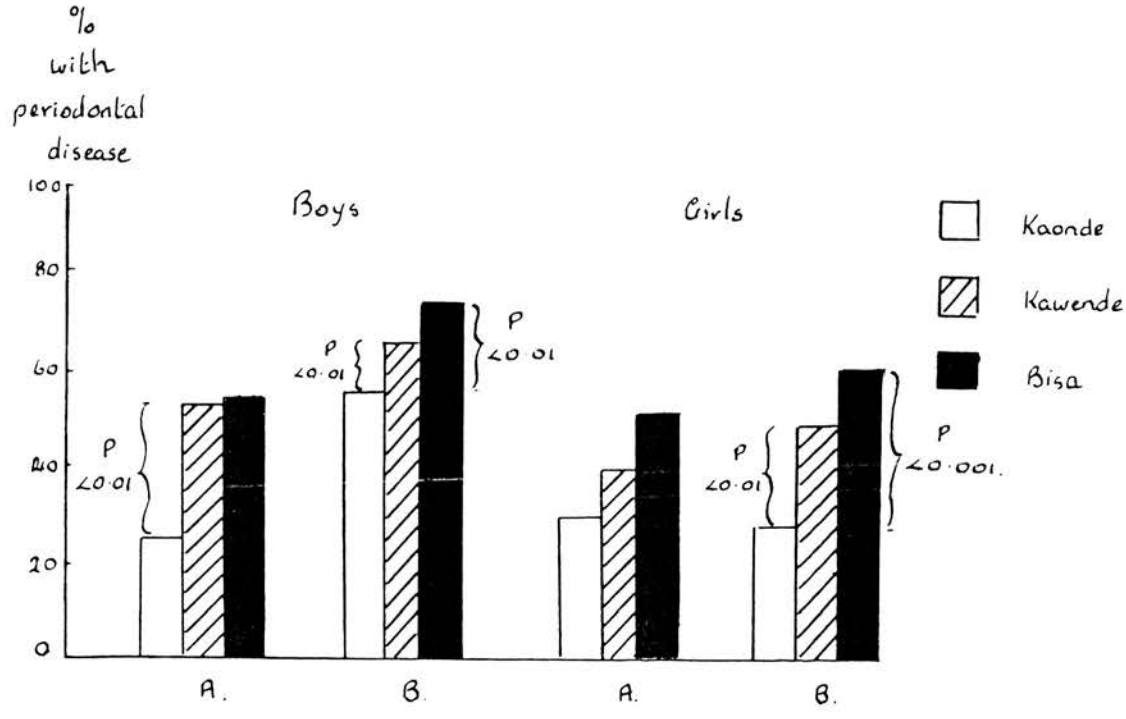
The effects of development on prevalence of periodontal disease for the three tribes are shown in Figure 18. The only group which did not exhibit an increase of periodontal disease prevalence with development was that of the girls of the Kaonde tribe, among whom the level of gingivitis remained almost constant while the level of pocketing decreased. This was traced to Nyoka school since no girls attending Mushima school had irreversible lesions.

Figure 18 Mouth Prevalence of Periodontal Disease, Gingivitis and Pocketing by Sex, Development, (Groups A and B) and Tribe.



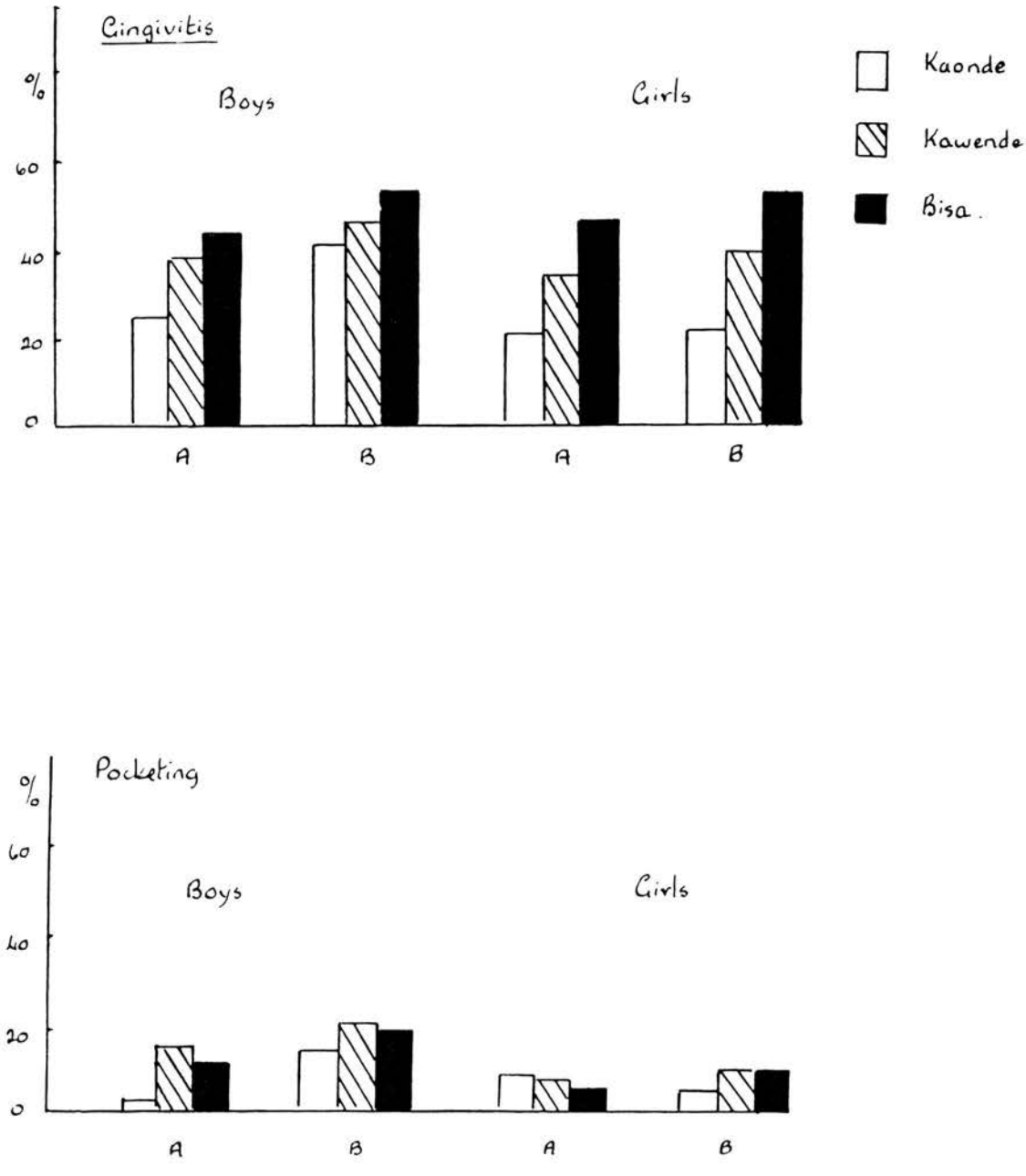
(iv) Prevalence of periodontal disease was consistently highest in children of the Bisa tribe and least among those of the Kaonde tribe (Figure 19).

Figure 19 Mouth Prevalence of Periodontal Disease by Sex, Development (Groups A and B) and Tribe



This pattern of tribal variation was consistently apparent in the distribution of mouth prevalence of gingivitis, but not in the distribution of pocketing (Figure 20).

Figure 20 Mouth Prevalence of Gingivitis and Periodontal Pocketing by Sex, Development (Groups A and B) and Tribe



[v] Analysis of the distribution of periodontal disease within tribes revealed an element of variation, particularly in the Kaonde and Bisa tribes, which indicated that periodontal disease status might be more related to school and possibly even to individual than to tribal structure alone. Thus gingivitis was consistently higher at Nyoka school than at Mushima school, while pocketing was higher at Mushima school in older boys. In the Bisa tribe gingivitis was consistently more prevalent at Kansansa school than at Mofu school, while pocketing was consistently higher at Mofu. No very clear picture emerged within the Kawende tribe.

B. PERIODONTAL DISEASE AND ORAL HYGIENE

[i] It is now recommended that assessment of periodontal disease status should include an assessment of the prevalence of soft deposits and calculus rather than the use of the OHI/S. For completeness of reporting the oral hygiene status expressed in terms of mouth prevalence of soft deposits and calculus are shown in Appendix V, Tables 13 and 14, but the OHI/S scores will be used for description and analysis.

[ii] A relationship between periodontal disease prevalence and oral hygiene status was indicated. Firstly, as shown in Table 35, by the fact that median OHI/S scores were consistently higher in boys than in girls (Group A - $P < 0.01$; Group B - $P < 0.001$).

Table 35 Median OHI/S Scores by Sex and Development (Groups A and B)*

	BOYS		GIRLS		
	N	**Median OHI/S Score**	**N**	**Median OHI/S Score**	
GROUP A	288	2.1	182	2.0	$P < 0.01$
GROUP B	627	2.5	343	2.0	$P < 0.001$
	915		**525**		

* from Appendix V Table 6.

Secondly, as shown in Table 36, the children of the Kaonde tribe who consistently showed the lowest disease prevalence (Figure 19) also consistently had the cleanest mouths.

Table 36 Median OHI/S scores by sex, development (Groups A and B) and tribe*

	KAONDE		KAWENDE		BISA	
	N	Median OHI/S Score	N	Median OHI/S Score	N	Median OHI/S Score
BOYS A	44	1.45	197	2.2	47	2.8
BOYS B	77	2.0	356	2.6	194	2.7
GIRLS A	26	0.4	118	2.0	38	2.1
GIRLS B	73	1.0	198	2.15	72	2.7

* from Appendix V, Table 6

A relationship was confirmed by comparing OHI/S scores in children with periodontal disease with those in children free of the disease (Table 37). Children with periodontal disease had consistently dirtier mouths than those free of disease.

Table 37 Median OHI/S Scores in Children with and without Periodontal Disease* by Sex and Development (Groups A and B)

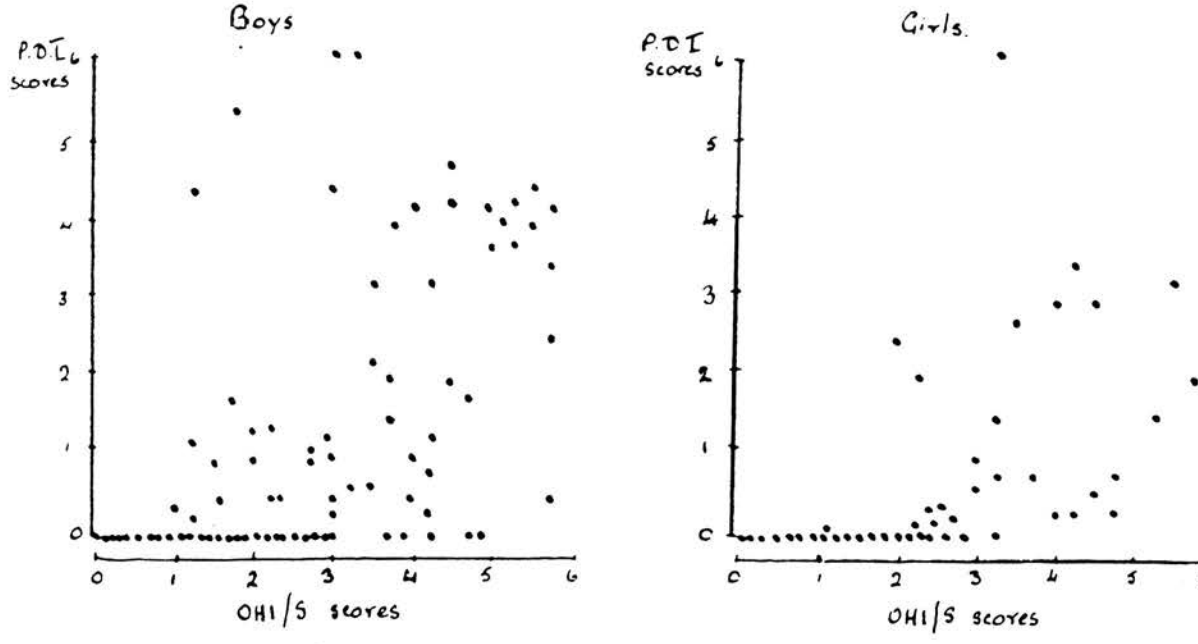
	Children with Perio Disease		Children without Perio Disease	
	N	Median OHI/S Score	N	Median OHI/S Score
BOYS A	139	3.5 **	149	1.4 **
BOYS B	417	3.5 **	210	1.3 **
GIRLS A	76	2.7 **	106	1.2 **
GIRLS B	165	3.5 **	178	1.0 **

* from Appendix V, Tables 6 and 15

** $P < 0.0001$

(iii) In order to assess the strength of the relationship, the individual PDI scores were plotted against the individual OHI/S scores for a 10 percent random sample of the total group (Figure 21).

Figure 21 PDI scores plotted against OHI/S Scores for a 10 Percent Random Sample



Although a trend was shown no clear linear relationship was apparent. Correlation procedures were therefore rejected in favour of an assessment of association. For this exercise the PDI scores were used as being clinically more sensitive than the basic assessment.

Accordingly the data were tabulated as shown in Appendix V, Table 16 and then grouped according to the clinical division of periodontal disease into reversible gingivitis and irreversible pocketing for paired analysis thus:

Class 1	children with	PDI scores	0 - 2.9
		OHI-S scores	0 - 2.9
Class 2	children with	PDI scores	3 - 6
		OHI-S scores	0 - 2.9
Class 3	children with	PDI scores	0 - 2.9
		OHI-S scores	3 - 6
Class 4	children with	PDI scores	3 - 6
		OHI-S scores	3 - 6

The clinical component of each class was therefore:

Class 1	children with no periodontal disease or reversible gingivitis only and relatively clean mouths.
Class 2	children with irreversible periodontal pocketing and relatively clean mouths.
Class 3	children with no periodontal disease or reversible gingivitis only and relatively dirty mouths.
Class 4	children with irreversible periodontal pocketing and relatively dirty mouths.

The results are shown in Table 38.

Table 38 Paired analysis of periodontal disease status in relation to oral cleanliness

BOYS

Number of Children

	TOTAL	CLASS 1	CLASS 2	CLASS 3	CLASS 4	χ^2 (1D.F.)	P
GROUP A							
Kaonde	44	39	0	4	1	1.52	n.s.
Kawende	197	131	2	37	27	53.77	< 0.001
Bisa	47	23	0	18	6	4.54	n.s.
TOTAL:	**288**	**193**	**2**	**59**	**34**	**69.48**	**< 0.001**
GROUP B							
Kaonde	77	47	6	19	5	0.57	n.s.
Kawende	356	180	13	98	65	54.81	< 0.001
Bisa	194	96	8	59	31	19.86	< 0.001
TOTAL:	**627**	**323**	**27**	**176**	**101**	**76.89**	**< 0.001**
TOTAL A + B:	**915**	**515**	**29**	**236**	**135**	**142.52**	**< 0.001**

GIRLS

	TOTAL	CLASS 1	CLASS 2	CLASS 3	CLASS 4	χ^2 (1D.F.)	P
GROUP A							
Kaonde	26	22	0	2	2	5.92	n.s.
Kawende	118	91	3	17	7	13.45	< 0.001
Bisa	38	27	2	9	0	0.002	n.s.
TOTAL:	**182**	**140**	**5**	**28**	**9**	**15.29**	**< 0.001**
GROUP B							
Kaonde	73	63	2	6	2	3.06	n.s.
Kawende	198	130	4	47	17	22.97	< 0.001
Bisa	72	38	0	27	7	6.48	n.s.
TOTAL:	**343**	**231**	**6**	**80**	**26**	**39.33**	**< 0.001**
TOTAL A + B:	**525**	**371**	**11**	**108**	**35**	**58.03**	**< 0.001**

The results showed a consistently strong relationship ($P < 0.001$) between periodontal disease and oral cleanliness in the groups where the numbers exceeded 100. In the smaller groups, i.e. the Kaonde tribe and Bisa girls, the association was not apparent at this level.

C. PERIODONTAL DISEASE AND TOOTH MALPOSITION

[i] As shown in Appendix V, Table 17, 384 children (27 percent) were classified as having malposition of permanent teeth to the degree shown in Appendix IV, Figures 3 and 4. No significant differences of distribution occurred between the sexes or among the three tribes.

[ii] Mouth prevalence of periodontal disease was consistently higher ($P < 0.001$) in children with malposition than in those with better arch form (Table 39).

Table 39 Mouth Prevalence of Periodontal Disease in Relation to Tooth Malposition

	With Malposition		Without Malposition	
	N	% with Perio	N	% with Perio
BOYS A	67	73.1*	221	40.7*
BOYS B	189	80.4*	438	60.5*
GIRLS A	32	71.9*	150	36.0*
GIRLS B	96	66.6*	247	41.0*

* $P < 0.001$

Differences were particularly marked in relation to mouth prevalence of periodontal pocketing where those children with

tooth malposition consistently showed more destructive disease ($P < 0.001$) than those with better alignment (Table 40).

Table 40 Mouth prevalence of Periodontal Pocketing in Relation to Tooth Malposition

	With Malposition		Without Malposition	
	N	% $\bar{c}$ Pocketing	N	% $\bar{c}$ Pocketing
BOYS A	67	39.0*	221	2.7*
BOYS B	189	52.4*	438	4.8*
GIRLS A	32	25.0*	150	2.7*
GIRLS B	96	25.0*	247	2.43*

* $P < 0.001$

Children with gross tooth malposition showed consistently higher OHI/S scores ($P < 0.01$) than those without such irregularities (Table 41).

Table 41 Oral Cleanliness in Relation to Tooth Malposition*

	With Malposition		Without Malposition	
	N	Median OHI/S Score	N	Median OHI/S Score
BOYS A	67	3.6**	221	1.9**
BOYS B	189	3.5***	438	2.2***
GIRLS A	32	2.3***	150	1.8***
GIRLS B	96	2.7***	247	1.8***

* from Appendix V, Tables 6 and 18.
** $P < 0.01$.
*** $P < 0.001$.

[iii] Examination of the periodontal disease status in children with relatively good oral cleanliness, i.e. OHI/S scores of under 3.0 showed that mouth prevalence of periodontal disease was consistently higher in those with tooth malposition (Table 42). Although the numbers were small in Group A.

Table 42 Mouth Prevalence of Periodontal Disease in Relation to Tooth Malposition in Children with OHI/S Scores of under 3.0

	Children with Malposition		**Children without Malposition**	
	N	**% with Perio**	**N**	**% with Perio**
BOYS A	30	43.3	165	26.7
BOYS B	77	57.1	273	41.0
GIRLS A	19	63.2*	126	25.6*
GIRLS B	49	44.9	188	25.5

* $P < 0.01$

Similarly, the children with OHI/S scores of under 3.0 showed a consistently higher prevalence of periodontal pocketing in those who also had gross tooth malposition (Table 43).

Table 43 Mouth Prevalence of Periodontal Pocketing in Relation to Tooth Malposition in Children with OHI/S Scores of Under 3.0

	With Malposition		Without Malposition	
	N	% c pocketing	N	% c pocketing
BOYS A	30	3.3	165	0.6
BOYS B	77	29.9*	273	0.73*
GIRLS A	19	15.8*	126	0.8*
GIRLS B	49	12.2**	188	0**

* $P < 0.01$

** $P < 0.001$

Closer examination of the degree of association between destructive periodontal disease and tooth malposition in relation to oral hygiene status was not possible owing to the lack of clinical definition in the diagnosis of malposition, the level of measurement and the small numbers involved.

PART FOUR - DISORDERS OF MUCOSA, TEETH AND BONE, AND DENTOFACIAL ANOMALIES

[i] One hundred and thirty-eight children presented with disorders of mucosa, teeth or bone as shown in Table 44

Table 44 Disorders of Mucosa, Teeth and Bone

	Boys	Girls	Total
Disorders of Mucosa			
Acute ulcerative gingivitis ...	1	-	1
Angular stomatitis	14	23	37
Candidiasis	9	4	13
Geographical tongue	1	-	1
Herpes labialis	30	17	47
	55	**44**	**99**
Defects of Teeth			
Fractured enamel	1	1	2
Fractured enamel plus dentine .	1	6	7
Gemination	1	1	2
Hutchinsonian incisors	-	1	1
*Hypoplasia	6	12	18
Supernumerary teeth	5	-	5
Tribal mutilation	1	-	1
	15	**21**	**36**
Disorders of Bone			
Alveolar destruction	1	-	1
Central Giant Cell granuloma ..	1	-	1
Maxillary fracture	1	-	1
	3	**-**	**3**
	73	**65**	**138**

* Dean's Class 4 (Dean 1934)

In addition, seven children had permanent teeth missing due to trauma. In the majority of cases, trauma resulted from bicycle accidents.

Despite the diagnosis of cancrum oris according to the criteria of Emslie (1963) in 46 pre-school children (2 percent of all those examined) no case was seen in the study group.

Some of the disorders listed in Table 44 are illustrated at the end of Appendix V.

[ii] In addition to the 384 children classified as having gross tooth malposition, a further three had dento-facial anomalies. These were one child with a unilateral cleft of lip, alveolus and palate: one child with an oro-nasal fistula in the upper right premolar region who lacked 5 4 1/ and had no history of trauma: and one child with partial anodontia. The last is illustrated in Appendix V, Figure 6, but the first two children refused to be photographed.

CHAPTER SIX - DISCUSSION

Interpretation and collation of findings

- dental caries
- periodontal disease
- disorders of mucosa teeth and bone, and dentofacial anomalies

Chapter Six

PART ONE - INTERPRETATION AND COLLATION OF FINDINGS

A. DENTAL CARIES

(i) Historically there are two indications that dental caries might be expected in Bantu children from remote areas of central Africa. Firstly, the teeth of Homo rhodesiensis, dating from 25,000 BC show a high level of carious attack (Woodward 1922, Powers 1968). Secondly, the early observations of Colyer (1916, 1917) recorded the presence of caries in similar children albeit at low levels.

In this study it was found that caries experience in permanent teeth for the total study group was again 'low'. In order to set this finding in the contemporary context recourse has been made to the W.H.O. Global Oral Epidemiological Data Bank since comparability in the literature is questionable owing to methodological differences. W.H.O. publishes figures for children of 12 years. Against these the findings for boys in eruption group VII, i.e. having 25-28 permanent teeth erupted have been selected as being the most representative and the closest in terms of development. When the figure of 1.79 DT per child for this group is viewed in the wider context as shown in Tables 45 and 46, it is apparent that this finding is within the spectrum of that which might be expected.

Table 45 Permanent Caries Experience in Rural Zambia in the Global Context*

Location	Sex and Development	Mean DMFT	Category**
Rural Zambia	Boys 25 - 28 permanent teeth erupted	1.79	Low
Europe	)	2.7 - 6.5	Moderate to high
North America	)	6.6	Very high
South America	) Both	4.5	High to very high
Australia	) Sexes	4.5 - 6.5	High
Asia	) 12 years	1.2 - 4.4	Low to moderate
Africa	)	0.0 - 2.6	Very low to low

* from Barmes 1981
** W.H.O. 1980a

Table 46 Permanent Caries Experience in Rural Zambia in Relation to Contemporary Findings from other African Countries*

Country	Sex and Development	Date	Mean DMFT	Category
Rural Zambia	Boys 25-28 Perm. teeth erupted	1967-68	1.79	Low
Angola	Both Sexes 12 years	1981	1.7	Low
Botswana	" "	1978	0.5	Very low
Burundi	" "	1976	0.7	Very low
Cameroons	" "	1978	1.1	Very low
Central African Republic	" "	1974	0.2	Very low
Ethiopia	" "	1958	0.2	Very low
	" "	1975	1.5	Low
Ghana	" "	1963-64	1.3	Low
	" "	1976	1.5	Low
Kenya	" "	1973-77	1.7	Low
Lesotho	" "	1980	1.3	Low
Liberia	" "	1978	0.6	Very low
Malawi	" "	1978	0.8	Very low
Mozambique	" "	1978	0.8	Very low
Nigeria	" "	1973	2.9	Moderate
Senegal	" "	1975	0.6	Very low
Swaziland	" "	1978	1.1	Low
Tanzania	" "	1973	0.6	Very low
Togo	" "	1973	1.6	Low
Uganda	" "	1966	0.4	Very low
	" "	1972	2.4	Moderate
Zaire	" "	1970	1.0	Very low
Zambia	" "	1971	0.1	Very low
Zimbabwe	" "	1972	0.6	Very low

* retrieved from W.H.O. Global Oral Epidemiology Data Bank.

However, analysis of the data from rural Zambia has shown that to quote a single figure for caries experience is an over simplification since four separate populations were identified, the figures being

Kaonde	3.38 DT / child
North Kawende	2.37 DT / child
South Kawende	1.45 DT / child
Bisa	0.91 DT / child

for boys in eruption group VII.

When considered in this form, the findings take on a different dimension since the 1.45 DT found in the boys of the Kawende tribe from the southern catchment of the Kapata peninsula, and the 0.91 DT for boys of the Bisa tribe can be more closely aligned with other findings from Africa than can the findings from the northern catchment of the Kapata peninsula and those from the Kaonde tribe. The 3.38 DT per child in the Kaonde tribe is the highest figure of caries experience reported from the Africa Region, outside of the Republic of South Africa (3.4 DT in 1978).

Clearly this comparison has an inherent weakness in the use of maturation for data grouping since eruption group VII contains boys up to the eruption of third molars, and hence the findings from rural Zambia may be inflated. However, the figure for the boys of the Kaonde tribe who had been almost completely isolated until the advent of the Flying Doctor Serivce is noteworthy and will be referred

to again at a later stage in discussion.

(ii) The findings concerning caries in the deciduous dentition are less informative than those for permanent teeth owing to the lack of younger children in the study group. Neither can they be viewed in the broad context in the same way as data are only stored for caries in primary teeth in the W.H.O. Global Oral Epidemiology Data Bank for children of 5-6 years. (Barmes 1981) Thus there is little to be said on this aspect of the report beyond the fact that the findings showed a previously unmet need for restorative care of deciduous teeth.

(iii) In finding that girls had slightly higher caries experience in permanent teeth than boys, this study was in accord with wider trends (Finn 1952), but this observation must be viewed with caution owing to the smaller number of girls in the study group. It is interesting that this situation was not found in the Kaonde tribe where the sexes were almost equally represented (boys 3.38 DT, girls 3.04 DT in eruption group VII). Since there was no apparent sociological reason for the difference in the Kawende tribe it would be of interest to study this question further without any possibility of sampling bias.

Given the previous lack of dental interference in these remote areas, the findings concerning caries experience may be regarded as a valid expression of past and present

attack. It was therefore to be expected that caries experience would be age-related as was the case. Had there been any significant socio-economic change which affected diet, such as that described by Akpata (1977) and Akpata and Jackson (1978) in Lagos, and by Jensen, Kizito, Langebaek and Nyka (1973) in Kampala, it would have been apparent. These observers all noted that in the urban situation caries experience was higher in younger children.

Again analysis highlighted the situation in the Kaonde tribe, where particularly among the boys cariogenesis was more active than in the other tribal groups.

(iv) These findings were the more remarkable given the extremely remote position of the Kaonde territory, where of all the locations of the study, there was confidence in there having been minimal western influences. When other group differences of this calibre have been identified in Africa it has also been possible to identify associated socio-economic factors (Colyer 1919; Oranje Noriskin and Osborn 1935; Osborn and Noriskin 1937; Staz 1938; MacGregor 1963, 1964; Akpabio 1966; Emslie 1966; Muldoon 1973; Enwonwu 1974), or to attribute the differences to the ingestion of fluoride (Møller et al 1972). Neither explanation could be applied in rural Zambia since the Kaonde children were very isolated and also had the small benefit of 0.2-0.3 ppm Fl in the well water. The finding of higher caries experience in children attending the more remote of the two Kaonde schools was a further

indication that factors other than proximity to urbanisation were involved.

It is recognised that frequency of eating may influence caries experience (Gustafsson, Quensel, Lanke, Lundqvist, Grahnene, Benow and Krasse 1954) and it was possible that the children of the Kaonde tribe might eat more frequently than the others since uncooked maize cobs were available. Had this been the case, a difference in caries experience might have been detectable between the day pupils and the boarders who were more rigidly supervised. No such difference was apparent.

It has been shown that Kaonde children had cleaner mouths than the others hence there was no possibility that the explanation of group differences was related to plaque accumulation, and had the sticks used for oral cleaning had antibacterial properties which might inhibit cariogenesis as suggested by Akpata and Akinrinmisi (1977) the reverse situation should have been found, i.e. the Kaonde children should have had less caries than the others, not more.

The only apparent explanation of the tribal variation in caries experience lay in differences of staple diet. The essential component of both maize as eaten by the Kaonde tribe and cassava as eaten by the other two tribes is starch which is generally regarded as being of low cariogenicity (Jenkins 1978), but differences of management could have affected the oral environment. It was observed that the maize cobs were

affected by spoilage, the chemical effects of which are decomposition under the influence of amylase enzymes with production of reducing sugars (Cox, McMasters and Rist 1947). It was therefore possible that the maize diet could contain sugars which would not be present in the cassava based diet.

The finding of differences in caries experience within the Kawende tribe supports this hypothesis. The higher levels found in the northern catchment of the Kapata peninsula could not be readily explained by proximity to urbanisation since intensive enquiries and personal inspection of the shops over a period of months failed to establish any geographical variation in the availability of refined foods.

Given the cultural and linguistic barriers it is possible that these investigations failed to reveal the true position but they were supported by the White Fathers of Twingi Mission who had a long standing and intimate knowledge of the area.

The most obvious dietary difference between the northern and southern catchments of the peninsula was that some maize was grown in the north but none in the south. The conditions of storage were the same as those of the Kaonde. Consequently the possibility existed that the children in the north of the peninsula also might consume a diet containing reducing sugars and this could account for the fact that their caries experience was more akin to that found in children of a different tribe living over 500 miles away, than it was to that found in children of the same tribe only a few miles distant.

No experiments concerning the cariogenicity of spoiled maize meal have been reported and therefore the supposition that maize as used in rural Zambia in 1967-68 was more cariogenic than cassava cannot be supported from other sources.

Differences between the Kawende of the southern catchment and the Bisa tribe cannot readily be explained in terms of staple diet for both were totally dependent on cassava. It has been shown that Bisa had more fresh protein than the other tribes, and some investigators into the interface of caries and nutrition have postulated that severe protein deficiency such as encountered in Zambia, may result in increased tooth susceptibility (Shaw and Griffiths 1963; Sweeney and Guzman 1966; Winter 1976). However, this hypothesis is as yet untested in human studies, and a far more likely explanation is that there was a difference in consumption of refined food between the Kapata peninsula and Mofu which was not necessarily detectable by European observers.

(v) The finding that caries in permanent teeth was largely confined to occlusal lesions in molars was in accord with other observations from Zambia (Desai 1973; Sims 1973a, 1973b; Andrick and Cech 1976) and there is general agreement that lower molars have suffered greater attack than uppers, as was found in this study.

However, opinions vary in the literature from Africa as a whole as to whether first or second molars are the more susceptible. Analysis of the findings in eruption group VII revealed that although more second molars than first molars were

carious in both maxilla and mandible, the differences only exceeded 99 percent confidence limits for lower molars in boys. This finding would therefore appear, despite earlier interest (Westwater 1977), to be of no great clinical importance.

B PERIODONTAL DISEASE

[i] Throughout the literature from the time of the earliest explorers, the prevalence, severity and early onset of periodontal disease in the indigenous peoples of Africa has excited comment. At one time it was supposed that a racial factor was involved (Russell 1957) but closer examination has not revealed this to be the case (Russell and Ayers 1960; Sheiham 1967). Current opinion (Manson 1980) is that poor socio-economic conditions and lack of oral hygiene are the primary factors. The findings of severe periodontal disease with early onset of pocketing in the study group was therefore not remarkable.

The problems of quantitative comparisons of periodontal disease status have already been discussed and it has been shown that difficulties of subjectivity in diagnosis which have been recognised for over 25 years (Russell 1956a) have yet to be overcome. Comparison of the findings from rural Zambia with those of others is resultingly an exercise of questionable value.

However, for the sake of completeness the findings of the basic assessment for the boys of eruption group VII are shown in Table 47 in relation to the contemporary data for other African countries retrieved from the W.H.O. Global Oral Epidemiological Data Bank. In view of the degree of inter-examiner error which has been demonstrated by Davies et al (1974) even in basic assessments, conclusions from this comparison are necessarily restricted.

Table 47 Periodontal Disease Status in Rural Zambia in Relation to Contemporary Findings from other African Countries*

Country	Age on Development	Sex	% Intense Gingivitis	% Periodontal Disease
Zambia - all	Er. Grp VII	M	45	20
Kaonde	"	"	40	14
Kawende	"	"	41	23
Bisa	"	"	54	18
Botswana	15 - 19 yrs	Both	51	1.0
Kenya	12 yrs	"	85	7.0
Lesotho	12 yrs	"	5	0.0
Malawi	12 yrs	"	37	2.6
Mozambique	12 yrs	"	97	1.7
Nigeria	10 - 14 yrs	"	23 - 73	0.0 - 73
Senegal	12 yrs	"	91	0.0
Somalia	12 yrs	"	0.0	0.0
Sudan	12 yrs	"	37	3.0
Swaziland**	12 yrs	"	73	4.2
Tanzania	12 yrs	"	84	0.0
Togo	12 yrs	"	75	25
Uganda	10 - 14 yrs	"	n.s.	10 - 15
Zaire	12 yrs	"	80 - 95	15 - 40
Zimbabwe	12 yrs	"	37	0.0

* retrieved from W.H.O. Global Oral Epidemiological Data Bank

** Klausen and Fanöe (1983)

The best that can be said is that findings from Africa apparently show a wide variation in periodontal disease status, and the findings from this study for prevalence of intense gingivitis fall very much in the middle of the range. The findings for prevalence of pocketing were towards the upper end of the range. It is possible that the findings for pocketing were inflated by the lack of distinction between true and false pockets in the basic assessment.

(ii) In finding that periodontal disease increased in prevalence and severity in older children and was generally more severe in boys than girls this study was in accord with the wider literature (Manson 1980).

As previously noted the finding of pocketing in very young children must be viewed with caution. The consensus of opinion in the literature from Africa is that destructive periodontal disease does occur in children but only Enwonwu and Edozien (1970) have also reported pocketing in children under 10 years of age. The findings from Zambia would have had greater value if they had been supported by case histories and possibly photographs, in which case the reported situation could have been explored in some depth. As it is the importance of these observations cannot be fully evaluated.

(iii) The association demonstrated between periodontal disease prevalence and oral cleanliness is also in accord with the wider literature but is of particular interest in the context, since only traditional aids to mouth cleaning were available. Other

observers in Africa have also found this to be the case (Emslie 1966; Sheiham 1966; Skougaard et al 1969; MacGregor 1978; Olsson 1978) but there is some debate concerning the use of twigs.

Emslie (1963), Sheiham (1966) and Henshaw (1974) have all criticised the relative inefficiency in the use of sticks; Emslie (1964b) finding sticks to be efficient only on vestibular surfaces. Waboso (1954) has discussed the use of sticks in some detail and postulated that the gingivitis may be damaged by this practice with lodged fibres leading to early pocketing. Fox Taylor (1965), MacGregor and Sheiham (1974) and Goracci (1980) have all supported this view.

The indications from Zambia were that the supervised oral hygiene regime practised in the schools of the Kaonde tribe was beneficial in terms of total prevalence of periodontal disease, but that the benefit was more clearly seen as a reduction of gingivitis rather than the prevention of pocketing.

(iv) The deterioration of oral cleanliness and peridontal health found in the presence of gross tooth malposition is of particular interest given the conflicting reports in the literature on this subject. Wheeler (1938, 1958) has reasoned that the displacement of curvatures in malposed teeth compromises the physiological protective system of the gingival crevice and produces food stagnation in areas of over protection. Since the association between oral cleanliness and periodontal health is well recognised, it would appear logical that tooth position should influence disease status as the findings from Zambia

indicate, but this has not been consistently observed.

The body of literature is almost equally divided between those who have found such a relationship and those who have not. Gould and Picton (1966) have postulated that this apparent contradiction may result from differences in group selection. Certainly an association has more consistently been found in numerically large groups such as those examined by Clements and Kirkpatrick (1938), Rosenweig (1960), Poulton and Aaronson (1961), McCombie and Stothard (1964) and Sutcliffe (1968).

In order to examine the position more closely Alexander and Tipnis (1970) conducted a comparative study between subjects who were highly dentally motivated, i.e. students and staff of a London dental hospital, and patients who were presumed to be less dentally motivated. They found that both groups showed an association between gingival inflammation and tooth irregularity, but the association was very much stronger in the patient group. From their findings Manson (1980) has concluded that dental motivation may obscure the issue, i.e. that where oral hygiene is good, tooth malposition may have little effect on periodontal health, but where oral hygiene is less than perfect tooth alignment may be a significant factor.

The finding of this association in Zambia where tooth irregularities were undisturbed by orthodontic interference and where dental motivation was low, would tend to support this contention.

This study is unusual in investigating the possibility

of an independent relationship between tooth position and periodontal disease, in this case destructive pocketing, and it is unfortunate that such small numbers were available for analysis, for on this subject also there is conflict in the literature. Sutcliffe (1968) has demonstrated greater mouth prevalence of gingivitis in children with good oral cleanliness who had anterior crowding than in those of equally good oral cleanliness but without crowding. Ainamo (1971) has found that malalignment has little effect on gingival health in the premolar and molar regions but may be a significant factor in the anterior maxillary region. Beagrie and James (1962) however have failed to establish that any independent relationship exists between tooth position and periodontal health.

In this study it was found that in children of OHI/S scores of under 3.0, more than three times as many children had pocketing (using the P.D.I. assessment) in the presence of gross tooth malposition than did those with better arch form. These differences were significant in older boys and younger girls ($P < 0.01$) and very striking in older girls ($P < 0.001$). These findings would appear to indicate the existence of an independent relationship between tooth position and pocketing but it may be that the oral hygiene status on the day of examination was not a true reflection of the previous history.

In advanced societies the importance of such a relationship is directly related to the philosophy underlying orthodontic treatment. This question is not applicable in rural Zambia where orthodontic treatment is likely to remain unavailable

in the foreseeable future. Therefore this aspect of the findings is of little practical importance, but the finding that oral cleanliness was worse in children with gross tooth malposition could be of considerable clinical value. The indications are that children with gross tooth malposition could usefully be made a target group in any future periodontal preventive programme.

C. DISORDERS OF MUCOSA, TEETH AND BONE, AND DENTOFACIAL ANOMALIES

(i) The reporting of disorders of mucosa, teeth and bone was not very informative since the field work pre-dated the introduction of the International Classification of Diseases in dentistry (I.C.D.-D.A.) (W.H.O. 1973), and diagnosis was restricted by the lack of laboratory facilities. In addition there was the likelihood that children suffering from more severe conditions would not be enrolled at school.

The absence of acute ulcerative gingivitis is a case in point, although widely reported from Africa only one child presented with this condition.

Another condition which might have been concealed in the community was incisor mutilation. It could not be discovered at what age this practice was carried out and the long term prospects for such insulted teeth were poor (Appendix V, Figure 4) but again only one school child with such teeth was examined.

The diagnosis of the mandibular central giant cell granuloma was made at Ndola General Hospital where the child was admitted, but he was removed by his family before surgery and did not return to his village so no follow-up was possible.

(ii) The classification of dentofacial anomalies in public health surveys is still a matter of individual judgment on the part of the examiner (W.H.O. 1977). Judgment in Zambia

was influenced by the lack of specialist services and as such, in the case of tooth malposition, of academic interest only.

Of the three other children so classified, the child with partial anodontia refused prosthetic treatment although, with the co-operation of a private dental technician in Lusaka, this was successfully carried out for adults at the rural base clinics. The other two children were admitted to Kabwe General Hospital for surgery which was carried out by the Consultant General Surgeon and the Government Dental Officer.

This aspect of the report demonstrates that there was a considerable burden of oral diseases and conditions in rural Zambian schoolchildren which would require specialist services to promote oral health, but it was likely that a greater burden might be concealed in the community. It was apparent that time and patience would be required for co-operation to be established, and only then could the true situation be evaluated.

PART TWO - IMPLICATIONS OF THE FINDINGS FOR THE PROVISION OF ORAL HEALTH CARE

INTRODUCTION

Three factors will be taken into consideration in this aspect of discussion. Firstly it is known that the Flying Doctor Service has not continuously employed a dental officer and the most recent available information (F.D.I. 1977) makes no reference to such a post. Consequently the children attending schools adjacent to the rural base clinics have not had the benefit of on-going oral health care.

Secondly, dental manpower in Zambia apparently still remains below the figure of 1:80,000 which is regarded as the minimum for the provision of even rudimentary public oral health services.

Thirdly, the findings of this study represent only a proportion of the burden of dental disease encountered, and there was and probably still is an unquantified demand for pain relieving services.

With these factors in mind, the findings will be considered in two situations: the first and most likely is in a situation of continued manpower deprivation, the second is in the situation where manpower resources have reached the basic minimum to allow a planned approach.

It is also taken into account that these findings pertain to the position in 1967-68 and there may have been radical changes in dental disease status in the interval.

(i) - in continued manpower deprivation.

In this situation it may be assumed that these remote rural areas would be totally deprived of oral health care personnel, and that procedures for relief of pain would be provided by medical or para-medical staff. No further epidemiological investigations would have been carried out and the findings of this study would be the only available data.

Taking first the caries findings for eruption group VII of

	Mean DT/child	
	M	F
Kaonde	3.38	3.04
Kawende N.	2.48	2.72
Kawende S.	1.39	2.12
Bisa	0.89	0.85

the indications are that no intervention would be required in the children of the Bisa tribe where the level was 'very low' or in the children of the southern catchment of the Kawende tribe where the level was 'low'. However intervention is indicated in the Kaonde children and those Kawende children from the northern catchment.

With no dental personnel available, conventional preventive intervention could not be carried out. However the findings of this study have indicated that the consumption of spoiled maize might be an aetiological factor in cariogenesis.

If that practice could be stopped the possibility exists that the 'moderate' level of caries experience could be reduced.

Clearly this could be achieved, and indeed may already have been achieved through improved agricultural and storage practice, promoted by the District Agricultural Officer. In which case an improvement in dental caries status might be effected in those areas where the caries level was 'moderate' without any active dental intervention, provided, of course, that the diet was still the same.

But changes in the diet were expected. All the indications during the field work were that rural development would introduce refined carbohydrates and thus a rise in caries experience could also be expected. If this were to be the case in the absence of dental personnel, any rise would be undetected and any benefit from improved maize management could be offset.

In the presence of malnutrition and hunger, it would be unlikely that dietary counselling against the consumption of refined carbohydrates by para-medical personnel could be effective, especially without the authoritative backing of a dental officer.

Thus in a situation of dental manpower deprivation, the reported caries levels might be maintained or even improved by non-dental intervention in the continued absence of refined carbohydrates, but should such foodstuffs be introduced there could

be no control.

Taking the periodontal disease findings for eruption group VII of

% with periodontal disease

	M	F
KAONDE	56%	29%
KAWENDE	65%	50%
BISA	74%	63%

% with debris

	M	F
KAONDE	94%	80%
KAWENDE	98%	95%
BISA	97%	93%

% with calculus

	M	F
KAONDE	89%	70%
KAWENDE	91%	89%
BISA	87%	88%

the indications are for a preventive programme which under the circumstances would have to be restricted to a school based programme of supervised oral hygiene using the traditional sticks.

It has been shown how such a scheme in the Kaonde schools was effective to a degree in reducing prevalence of periodontal disease especially among the girls. If this were to be extended to all schools under the auspices of the Inspector of Schools and maintained, an improvement in periodontal health might be expected.

Furthermore, the findings indicate that such a programme could be more effective if particular attention were to be given to those children with gross tooth malposition which is readily apparent to non-dental personnel.

In a situation of continued dental manpower deprivation, the position would therefore be that simple preventive measures could be applied through other agencies. At the reported disease levels the possibility exists that these measures could provide an acceptable degree of disease control in schoolchildren, under the existing circumstances. Lack of surveillance could allow caries levels to rise un-noticed, and no provision could be made for an increased burden of disease.

(ii) - if manpower resources reached the basic minimum for a planned approach

In order to reach the 1:80,000 level of staffing, it would be necessary for Zambia to recruit 35 more dentists, an increase of 200% on the current establishment. If the recruited dentists were to be distributed throughout the country in proportion to the population it would mean that the 70 percent of the population living in the rural areas should be served by 44

dentists (working on the current population figure of 5,000,000 Taylor 1982). It is unlikely that such even distribution would be possible but even if the six predominantly rural provinces were staffed by four dentists each, it would represent a significant improvement.

It should then be possible for a dental officer to be based at Mansa in the Luapula Province, Luwingu in the Northern Province and Solwezi in the North-Western Province. This would base a dental officer within 200 miles of each of the rural locations of this study. (Appendix III, Figure 1).

Given the lack of epidemiological data, it would be necessary for each dental officer to survey his catchment area to establish dental needs. Carried out on the 'Pathfinder' principle (W.H.O. 1977) this need not be too time consuming, apart from travelling time, and at the same time an estimate could be made of demand from the existing records of the medical personnel. As the data from this oral health survey are now out of date, it would be necessary to re-examine children from the study areas which would have the benefit of monitoring disease trends in the intervening years.

It might be envisaged that treatment on demand for relief of pain would remain the responsibility of medical personnel until such time as dental personnel were trained for this task, but referral paths could be devised to involve the dental officers whether at base hospitals or on tour.

In this situation a structured approach could be applied in the rural areas.

In terms of dental caries, if the findings remained the same, surveillance only would be indicated for the cassava eaters, but the introduction of preventive measures would be indicated for the maize eaters as before. If survey results showed changed of caries experience, surveillance or prevention would be selected as appropriate.

Selection of the method of caries prevention in the unusual conditions of the rural areas would have to be approached with caution. Water fluoridation, fluoridated toothpastes, milk or fruit juices would clearly be out of the question. Similarly, any procedures of topical application involving trained dental personnel could not be considered in the foreseeable future. Fluoridated salt would be of doubtful value unless availability was assured. The choice would therefore be restricted to the systemic application of fluoride in the form of tablets or topical application in the form of mouth rinsing with fluoride solutions.

Both methods have been shown to effect substantial reductions in caries experience, but on balance the evidence is that systemic application provides the greater benefit, even when administration of tablets does not start until the age of six years, or is intermittent. (Davies 1974) These factors would have to be taken into consideration since supervision of any caries preventive programme in the areas of this

study would inevitably devolve upon the school staff, and could be only undertaken in term time.

It might be confidently predicted that school staff would prefer the administration of daily tablets to the supervision of rinsing, in that the time required for the former is very much less, and no extra equipment would be needed. Since their co-operation would be vital to the success of the programme, their attitudes would influence the choice.

On the question of possible abuse, the choice would again favour the use of tablets. Given proper security the risk of theft and hence abuse could be minimised. Given reasonable care in supervision the proper dose to each child could be controlled. With a programme of mouth rinsing it could be very difficult to ensure that the solution was not swallowed.

There is no doubt that transport and supplies might be extremely difficult in either case. This would have to be investigated in detail and a suitable course adopted for each situation. Again the difficulties of supplies would weight the argument in favour of tablets, since only they would have to be transported. In a mouth rinsing programme, there would be the question of cups to be considered, and the programme might founder on that issue alone.

Finally, in a minimal resource situation, serious consideration would have to be given to cost benefit. Again the evidence from the literature (Davies 1974) is that tablets would be the preferred option.

If the findings for the prevalence of periodontal disease remained the same, intervention would be indicated for all groups except girls of the Kaonde tribe. It has already been shown that the school oral hygiene programme was effective among the Kaonde girls such that an extension of this approach would be indicated.

Had such an extension occurred and an improvement was generally found in prevalence of periodontal disease to a 'moderate' level, further preventive action would not be indicated.

However, since dental hygienists would not be available for the foreseeable future, a programme of pre-school instruction in oral hygiene would be advantageous, to prevent the formation of calculus in the years before a child might otherwise receive instruction. Such measures might best be effected through the channels of ancillary medical staff at mother and baby clinics.

Ancillary medical staff could also be encouraged to give dietary counselling both in the clinics and at the schools and it might be appropriate to introduce school programmes such as that recently described from Kenya (Stephen 1982) where the children themselves assume the role of educators.

Transport would be required for each dental officer for rural tours which would involve the use of a landrover or similar vehicle and possibly mopeds for more remote areas. Where travel by water was required, canoes could be used as they were during the course of the field work for this study.

Great care would have to be given to the supplies of fluoride to the schools which might either be organised in conjunction with the education department, or by the employment of special messengers for this purpose alone who would be responsible to the dental officer. Alternatively, the medical supply routes could be used making the rural medical assistants responsible for delivery to the schools. The responsibility for organising supplies would probably lie with the individual dental officer.

In the long term it might be envisaged that each dental officer would head a team of suitably trained dental auxiliaries (W.H.O. 1980b) such as are currently used in neighbouring Mozambique (Hobdell 1981). It would then be possible to remove the burden of pain relieving services from medical personnel and to establish close liaison with schools and other non-professional personnel involved in any aspect of oral health care. The preventive approach indicated by the findings of this study could then be implemented as part of a planned oral health care programme.

CONCLUSIONS

1. Basic field conditions and lack of social organisation in a primitive society constrain but do not necessarily preclude useful dental epidemiological study. In rural Zambia the value of clinical findings was limited by the lack of chronological age as the basis for data grouping.

2. In broad terms dental disease status in rural Zambian children accorded with other observations from Africa, with caries being at low to moderate levels, and periodontal disease being high.

3. By use of maturation for data grouping, analysis within the study group indicated that the staple foodstuffs, maize and cassava might have differing roles in cariogenesis. The possibility is raised that the greater cariogenicity of maize might have resulted from the enzymatic processes in spoilage.

4. Periodontal disease was found to be associated with both oral cleanliness and gross tooth malposition, but investigations into the possibility of an independent relationship between periodontal pocketing and tooth malposition were inconclusive owing to the small numbers available.

5. Provision of oral health care in the rural areas of Zambia was virtually non-existent at that time and there are no indications that the position has radically changed. The clinical findings indicated that a planned preventive approach would be appropriate given adequate professional staffing. However, it

would appear to be unlikely that even the basic minimum of one dentist to 80,000 population will be achieved in the foreseeable future. In which case the oral health of rural populations will remain largely a community responsibility without the benefit of professional supervision.

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